1936.

THE DECEMBER SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

THE PRESENT STATUS OF COSMOLOGY. PROFESSOR RICHARD C. TOLMAN 491

THE RELATION OF ORGANISMS TO THE SALTS OF THE OCEAN. PROFESSOR LAURENCE IRVING 508

THE CONTRIBUTION OF CHOLERA TO PUBLIC HEALTH. PROFESSOR J. HOWARD BEARD 515

IN QUEST OF GORILLAS. DR. WILLIAM KING GREGORY. XIII. H. C. RAVEN 522

ARBORETA, OLD AND NEW. JOHN G. JACK 541

THE PROBLEM OF THE ORIGINS OF ALCHEMY. PROFESSOR TENNEY L. DAVIS 551

THE WORLD'S FOOD AND THE ARGENTINE BIRTH RATE. DR. SIMON G. HANSON 559

CONSERVATION AMONG PRIMITIVE HUNTING PEOPLES. WILLIAM CHRISTIE MACLEOD 562

UNITED STATES AND BRITISH UNITS OF WEIGHTS AND MEASURES. HENRY W. BEARCE 566

PLANKTON AND INVERTEBRATES OF THE ANTARCTIC. DR. EARLE B. PERKINS 568

THE PROGRESS OF SCIENCE:

The Christmas Meeting of the American Association; The Meeting of the Founder Societies of the American Institute of Physics; Retirement of Professor Raymond Dodge; The Television Demonstration; The Non-Inheritance of Allergic Diseases; Methylene Blue as an Antidote for Cyanide and Carbon Monoxide Poisoning 575

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WARE CATTELL, Associate Editor

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THE PRESENT STATUS OF COSMOLOGY[1]

By Professor RICHARD C. TOLMAN

THE CALIFORNIA INSTITUTE OF TECHNOLOGY

THIS article attempts to give a qualitative account of the present status of cosmology. I wish to begin by raising objections to my own title, on account of the inclusion of that very dangerous term, "cosmology." It is a word which has a long background of dubious metaphysical association, and seems to imply the treatment of the whole universe as a unit, by some method which far transcends the limitations of ordinary observation. But a knowledge of the *whole* universe is certainly given to no man, and its treatment as an understood *unit* is possible to no man—not even to a philosopher. Whatever philosophers may

[1] Adapted from the presidential address to the Pacific Division of the American Association for the Advancement of Science, June 17, 1936.

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FIG. 1. HAWQUAL'S MAP OF THE WORLD AS RECONSTRUCTED BY J. T. REINAUD.

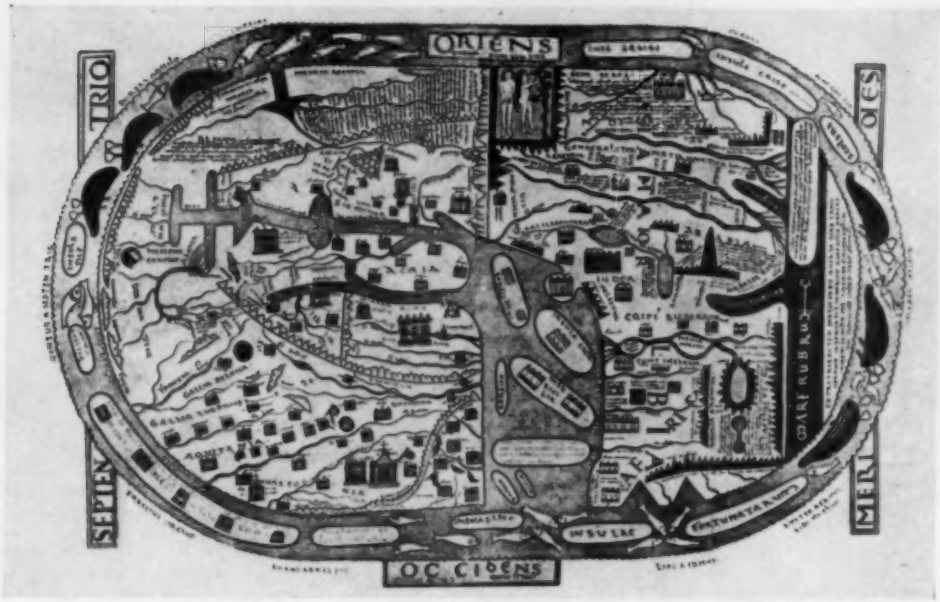

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FIG. 2. MAP OF THE WORLD ACCORDING TO BEAUTUS.

do, and indeed I think should do, it seems imperative that those of us who are scientists should write only on subjects concerning which we have specific observational knowledge. Hence for the purposes of this article I shall ask you to regard the word "cosmology" as quite a modest one, implying the study and scientific treatment of our physical surroundings, out as far as our telescopes have penetrated, with only the most guarded extrapolation to further distances or to matters that we have not yet observed.

With this meaning of the word, it is evident that cosmology will be a continually growing branch of science, passing through different stages of development as we obtain the possibility of observing more and more distant astronomical objects. I have provided a number of illustrations to denote these different stages in the development of ideas as to cosmology and to show the nature of the different astronomical objects which we have been able to observe. These latter range all the way from our own moon, which is the nearest of all, to the distant nebulae which lie far beyond the stars in our own milky way or galaxy. The illustrations come from several sources, including two from the Huntington Library, but most of them have come from the Mount Wilson Observatory, where I have had the kind and expert advice of Dr. Hubble in making selections.

The Cosmology of a Flat Earth

In very ancient days, before the science of the Greeks, the knowledge of man was closely limited by his immediate surroundings. His ideas of cosmology were self-centered and, so to say, parochial. The world consisted of his own country, large and important, surrounded by other lands of lesser size and value, and all in turn surrounded by an unknown ocean. The earth was flat, mariners should keep near shore lest they fall over the edge, and the sun, moon and stars rose from beyond the ocean to give us a

light by day and by night, and sank again to return under the earth ready for the start of a new journey.

Such ideas, still possible for backward folk, persisted for most men long after there was a good scientific tradition to the contrary, and I have secured two ancient maps of the world to illustrate this stage of cosmology—one a Moslem map first drawn in the tenth century by a traveler from Bagdad named Quasim Muhammad Ibn Hawqual—the other a Christian map first drawn in the eighth century by a priest of the name Beautus Libaniensis.

FIG. 3. OLD CUT ILLUSTRATING PTOLEMAIC SYSTEM.

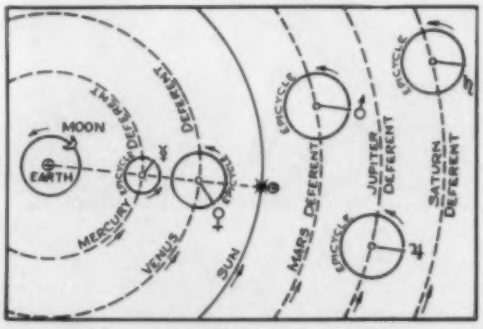


FIG. 4. PTOLEMAIC SYSTEM.
SIZE OF ORBITS ARBITRARY.

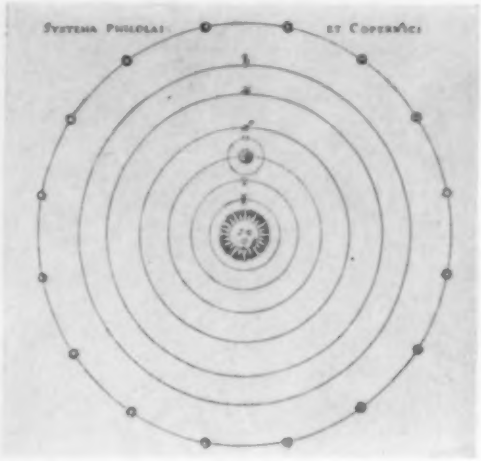


FIG. 5. OLD CUT ILLUSTRATING COPERNICAN SYSTEM.

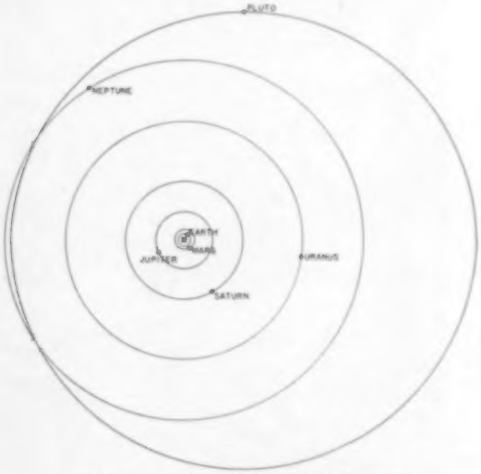


FIG. 6. THE SOLAR SYSTEM
DRAWN TO SCALE WITH THE POSITIONS OF THE PLANETS AS OF JANUARY, 1936.

My first illustration, Fig. 1, gives the map of the whole world as it seemed to the Bagdad geographer Hawqual. The lettering has been put in at a later time in French, north lying as you see to the left, and south to the right. The Moslem influence is evident in the highly geometrical character of the contours. The curved horn to the south—that is, to the right—is the continent of Africa; the straight wide Nile flows into the Mediter-

FIG. 7. NORTHERN PORTION OF MOON,
AGE 18 DAYS, TAKEN AUGUST 7, 1925, WITH THE MOUNT WILSON 100-INCH REFLECTOR.

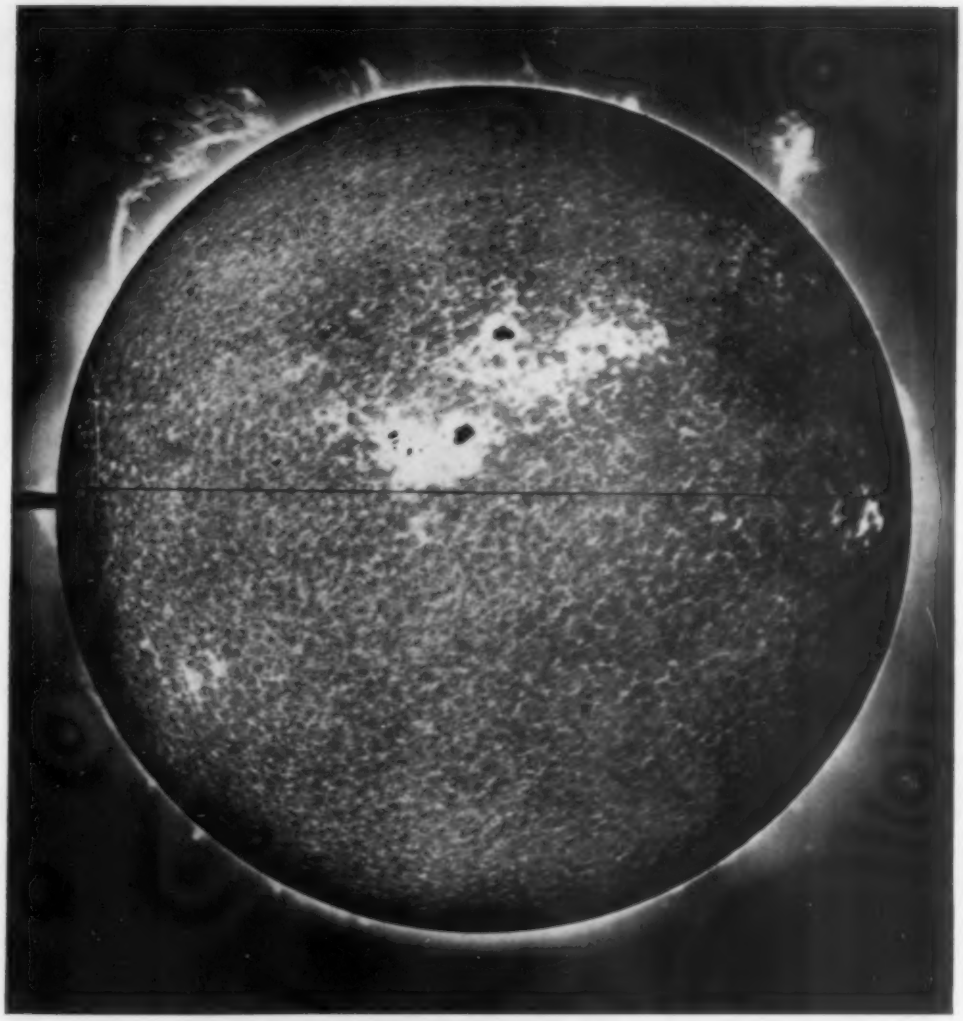


FIG. 8. SURFACE OF SUN

TAKEN AT MOUNT WILSON WITH THE LIGHT FROM CALCIUM ATOMS.

ranean—with three round islands, Cyprus, Crete and Malta. The parochial point of view is indicated by the great extent of Moslem countries on the Indian Ocean and Gulf of Persia, with little Europe and the empire of China crowded to the west and east. This point of view was also expressed in Hawqual's writings:

> I have described the earth in its length and breadth; I have given a view of the Moslem provinces; but have taken no account of the division by climates, in order to avoid confusion . . . in a word, I have collected all that has ever made geography of interest either to princes or peoples. I have not described the country of the African blacks and the other peoples of the torrid zone; because naturally loving wisdom, ingenuity, religion, justice, and regular government, how could I notice such people as these, or magnify them by inserting an account of their countries?

The second illustration, Fig. 2, shows the whole world as it appeared to the

monk Beautus, again with north to the left and south to the right, and again with all the lands of the earth surrounded by the unknown ocean, this time taken as filled with mythical islands, many fish and some quite strange-looking rowboats. The local point of view is now shown by the great size ascribed to Europe with its houses and churches; and the Christian influence is made evident by the Garden of Eden, where you can see Eve just picking the apple from the tree of knowledge to give to an eager Adam.

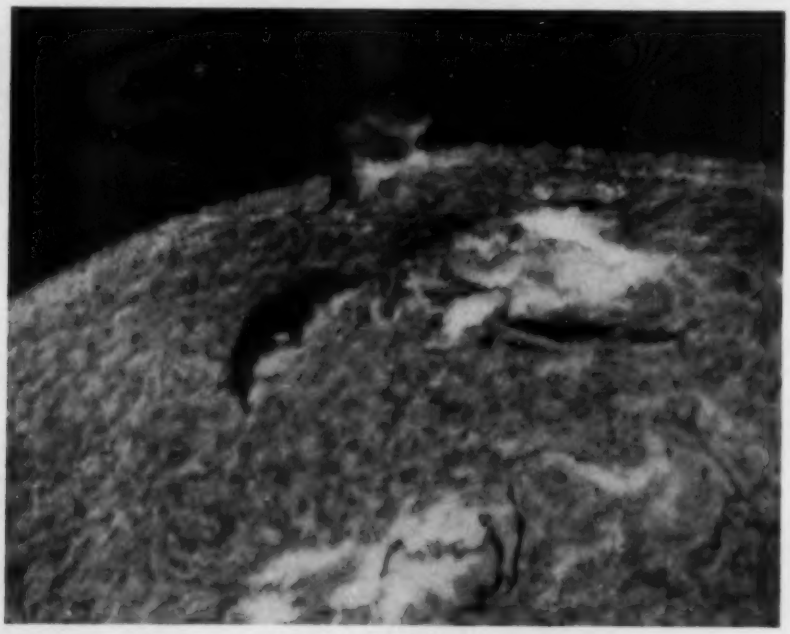


FIG. 9. SURFACE OF SUN

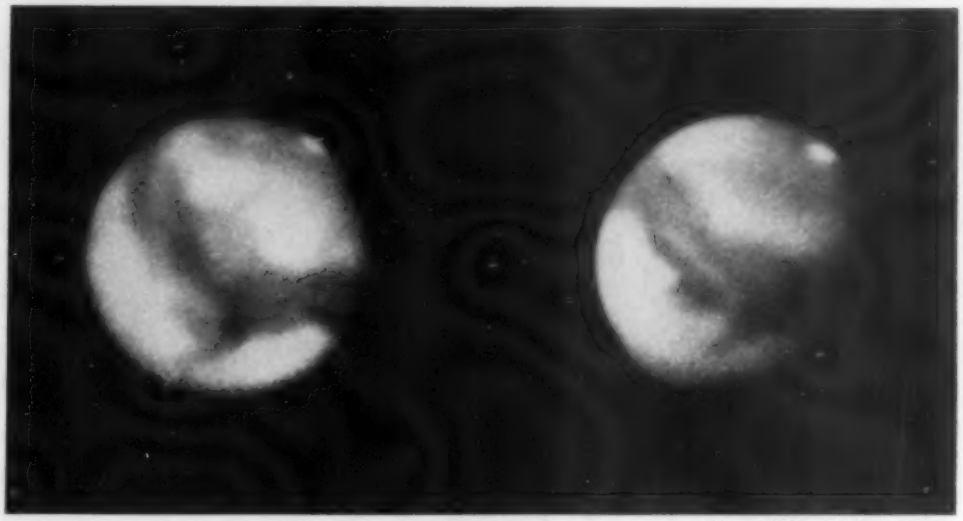
TAKEN AT MOUNT WILSON WITH THE LIGHT FROM HYDROGEN ATOMS.

THE PTOLEMAIC SYSTEM

These maps of a flat earth represent a very early stage of cosmology, but long before these particular maps were drawn the science and philosophy of the Greeks had led to much more acceptable ideas. These ideas were presented with great detail and completeness about the year A.D. 140 by the Alexandrian mathematician, geographer and astronomer, Ptolemy; and for fourteen centuries the Ptolemaic system, as described in his great book, the Almagest, provided the accepted cosmology of the really learned.

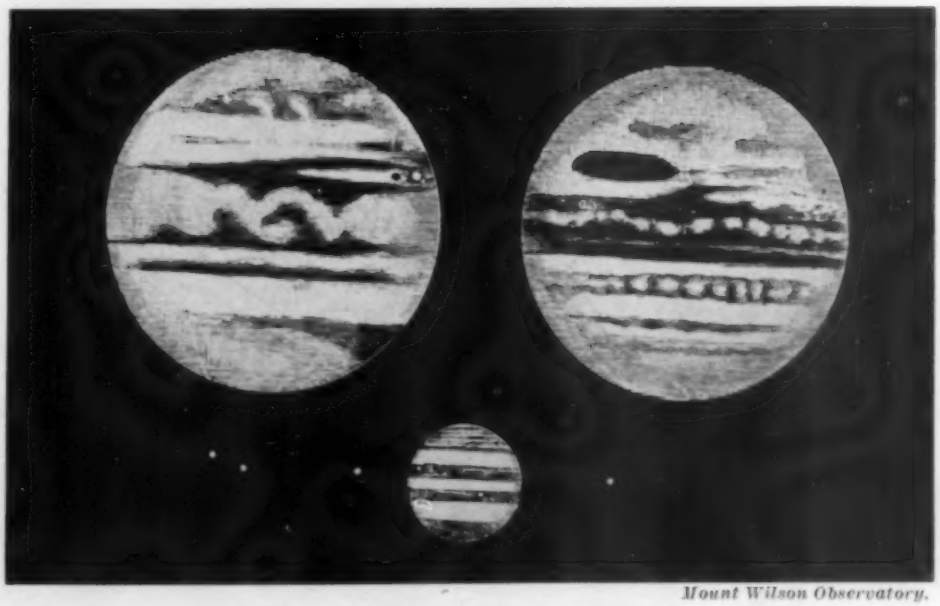
I have taken a cut, Fig. 3, from an English book of the time of Charles the Second to illustrate the Ptolemaic stage of cosmology. I am a little hesitant about introducing it, because the old drawing does not give a true impression of those satisfactory scientific features which were successfully treated by Ptolemy. At the center of the system is the earth, recognized by Ptolemy to be a sphere of land and water of somewhere near its true size. Outside the earth are spheres of air and fire, in accordance with the Greek philosophy as to the behavior of earth, air, fire and water, and outside these are the heavenly bodies moving in great circles—the moon, Mercury, Venus, the sun, Mars, Jupiter and Saturn, and finally the stars of the firmament in the order named.

For Ptolemy the earth was at rest and



Mount Wilson Observatory.

FIG. 10. PHOTOGRAPHS OF MARS.



Mount Wilson Observatory.

FIG. 11. DRAWINGS OF JUPITER.

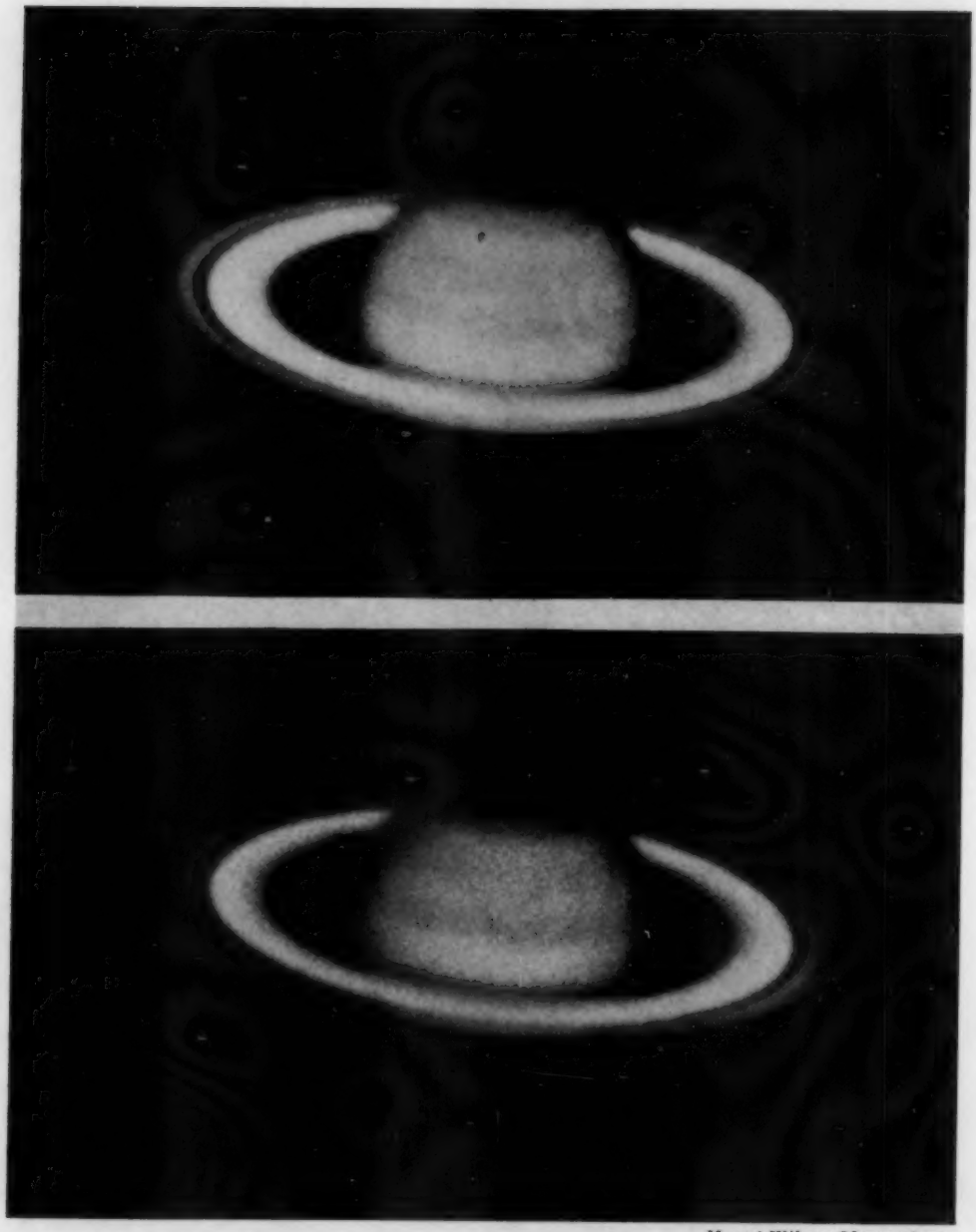


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FIG. 12. PHOTOGRAPHS OF SATURN.

Mount Wilson Observatory.

FIG. 13. PHOTOGRAPH OF HALLEY'S COMET.

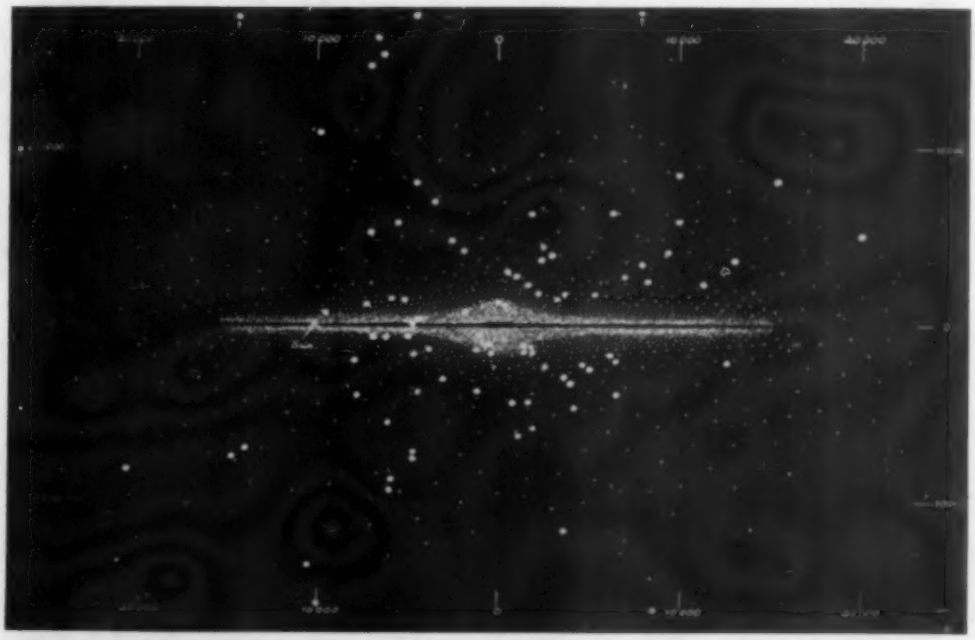


FIG. 14. MODEL OF THE GALAXY

FROM THE HALLEY LECTURE DELIVERED ON JUNE 5, 1935, BY J. S. PLASKETT.

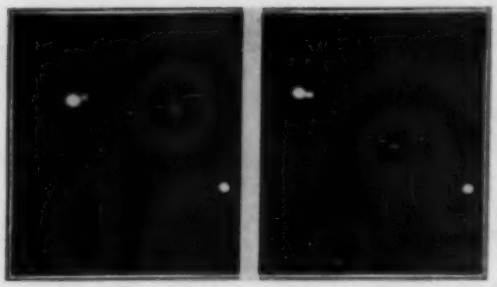


FIG. 15. THE TRIPLE STAR KRÜGER 60. TWO PHOTOGRAPHS, FIVE YEARS APART, MADE BY BARNARD AT THE YERKES OBSERVATORY.

at the center of things, and the rising and setting of the sun, moon and stars was due to the revolution of the whole heavens around the earth once every twenty-four hours. In addition to this rapid daily revolution there was a further slow motion in great circles called "deferents," and in small circles called "epicycles," as shown by the somewhat more scientific looking diagram, Fig. 4; and these combined motions gave a very fair account of actual observations.

It seems to us now that Ptolemy was very local minded in making our own earth so important, so central and so fixed. Nevertheless, from a phenomenological point of view his system did describe his observations, and from a modern theoretical point of view, that of Einstein's general relativity of motion, we do not characterize Ptolemy's mode of approach as wrong but merely as very inconvenient and extremely complicated.

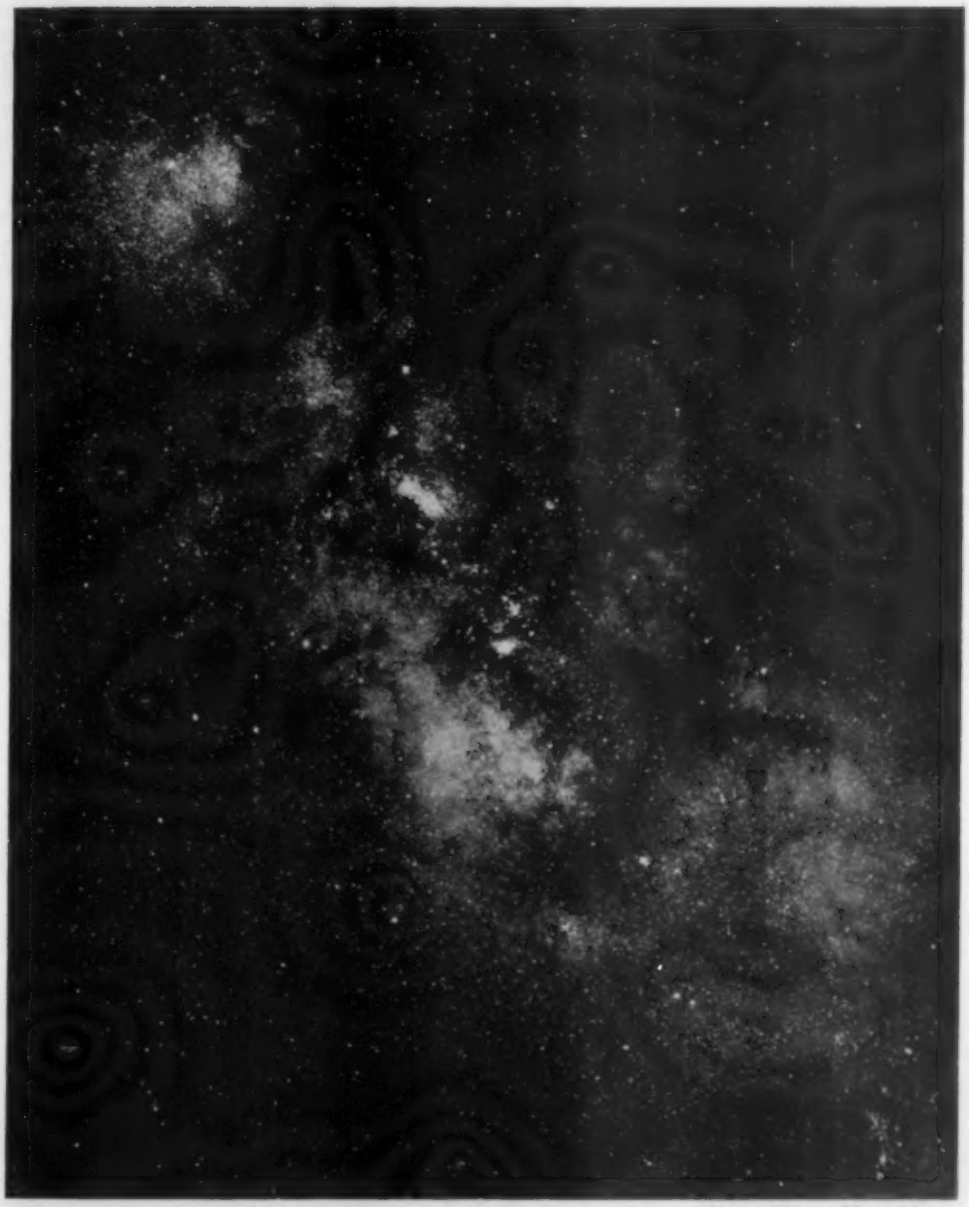
THE COPERNICAN SYSTEM

The learned world had to wait a long time, nevertheless, before it was ready for intellectual clarity and simplicity. The idea that man's earth was not the center of all things seemed altogether too contrary to common sense, to human importance and to revealed religion. Finally, however, in the year 1543 the publication of the great work of Copernicus, "On the Revolution of the Heavenly Bodies," gave that exhaustive treatment necessary for the change to a new point of view.

Fig. 5, also from the time of Charles

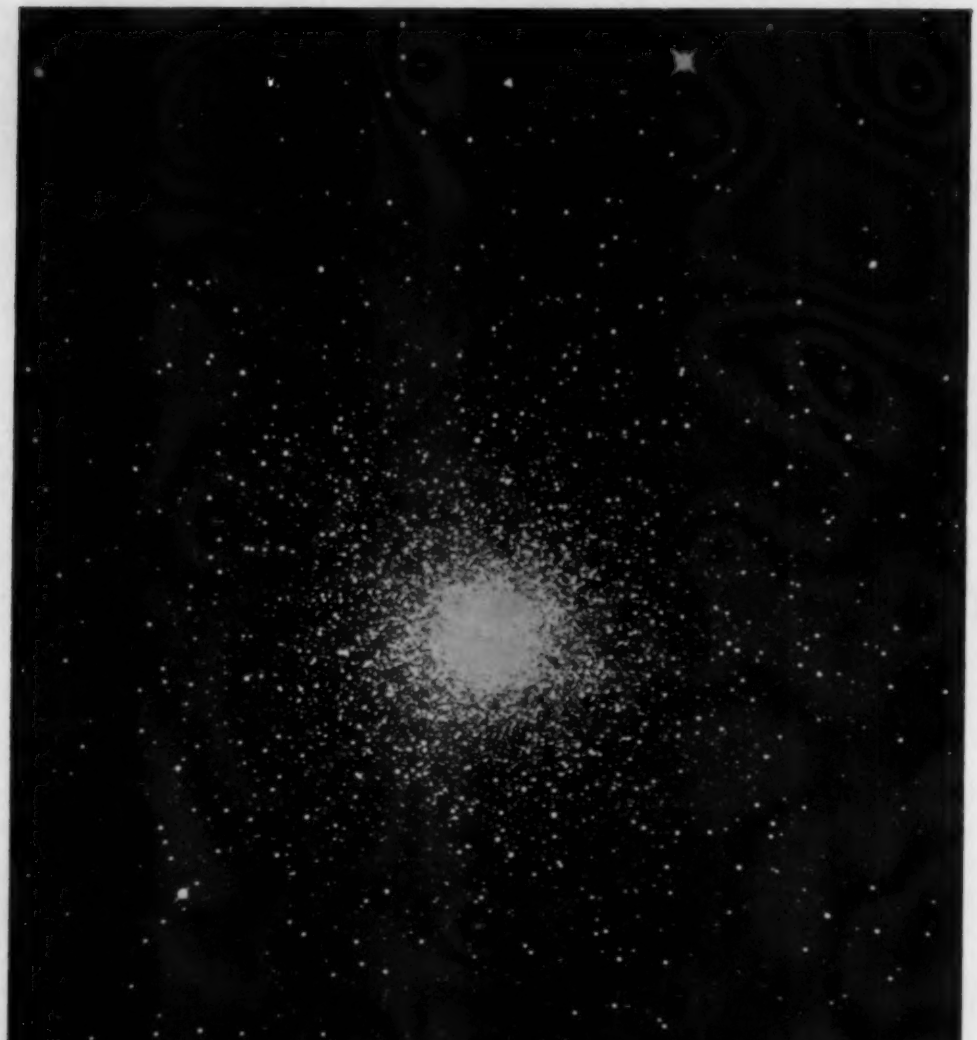
Mount Wilson Observatory.

FIG. 16. TWO DIFFERENT EXPOSURES OF OPEN CLUSTER OF STARS, MESSIER, 35.



Mount Wilson Observatory.

FIG. 17. STAR CLOUDS IN SAGITTARIUS.



Mount Wilson Observatory.

FIG. 18. GLOBULAR CLUSTER OF STARS, MESSIER 3.

Mount Wilson Observatory.

FIG. 19. ILLUMINATED MATERIAL IN ORION.
THREE HOURS' EXPOSURE ON THE 100-INCH REFLECTOR.

the Second, pictures the Copernican system. The sun—as you see, a very friendly one giving light and heat to man—now furnishes the center for the revolution of the earth and all the other planets; and a simple rotation of the earth itself, once every twenty-four hours on its own axis, is all that is needed to explain the rising and setting of the sun, the moon, the planets and the million other suns called stars.

The Copernican ideas of the solar system are practically those we hold to-day. They have been extended first by the finding of Kepler that the planetary motions are not quite circular, but rather slightly elliptical, with the sun at one focus of the ellipse; secondly, by the gravitational theory of Newton, which accounts for planetary motions with the help of an inverse square law of attraction; and finally by the improved gravitational theory of Einstein, which gives the results of Newton as a close approximation, but then goes on to the treatment of phenomena not included in Newtonian theory. The next illustration, Fig. 6, gives a more modern diagram of the solar system, showing to scale the orbits of the earth and other planets, including the little planet Pluto, discovered in 1930 at the Lowell Observatory in Arizona. The diagram has to leave out the orbits of Mercury and Venus, which are inside that for the earth. It also has to omit the stars, since they are of course far beyond the confines of the solar system; the distance

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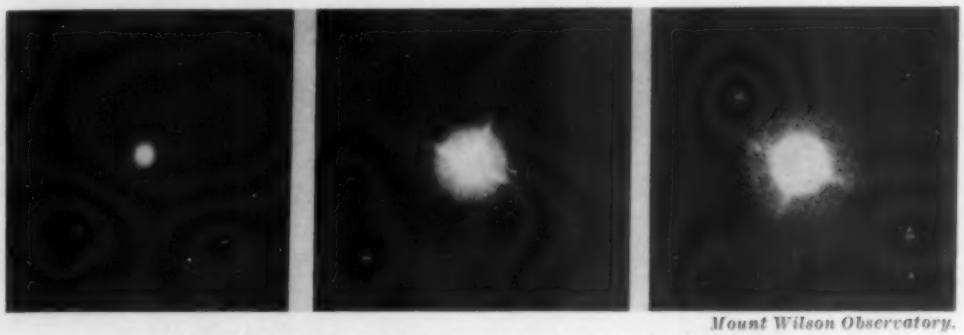
FIG. 20. DARK AND ILLUMINATED MATERIAL IN ORION.

THREE HOURS' EXPOSURE ON THE 100-INCH REFLECTOR.



Mount Wilson Observatory.

FIG. 21. EXPANDING RING AROUND NOVA AQUILAE,
APPEARING FIRST IN 1918, TAKEN IN 1922, 1926 AND 1931 WITH 100-INCH REFLECTOR.

to Proxima, the nearest star we know, is 7,000 times as far as that to the outermost planet, Pluto.

I now wish to show you some actual photographs of astronomical objects in the solar system, that is, in the neighborhood of our own sun, the star around which we ourselves revolve. First of all we have the moon, for us the nearest object of all, and of special interest to astronomers since its distance and rate of revolution around the earth furnished Newton with the needed quantitative test for his theory of gravitation. Fig. 7 gives a portion of the moon's surface near enough so that you can see its mountains, plains and characteristic craters. Next, Fig. 8 and Fig. 9, we have two photographs of the sun, showing sunspots, faculae, flocculi and giant bursts of vapor from the surface. By making use of the spectroheliograph invented by Dr. Hale, these photographs were taken, the first with the light emitted from calcium atoms in the sun's surface, and the second with the light from hydrogen atoms. And now, Figs. 10, 11 and 12, three of the planets: Mars, with its surface markings and polar cap of snow, two views, one time partially and one time completely illuminated by the light of the sun; drawings of Jupiter, with its belts and four of its eight moons; and two views of Saturn with its rings, both taken on the same night. Finally, as another kind of member of the solar system, Fig. 13, Halley's Comet, one of those conglomerations of particles, dust and gas which periodically sweep in close around the sun in their long and narrow elliptical orbits.

The Stellar System

So much for typical objects in the neighborhood of the sun. But the sun is only one star out of many, big and bright for us because of nearness, but far surpassed in absolute size and luminosity by numerous others. Hence for the next stage of cosmology we must turn to the study of the milky way or galaxy, of which our sun is only one unimportant member.

As I prefaced the earlier stages of cosmological study with maps of the "flat" earth and with diagrams of the Ptolemaic and of the Copernican systems, so I can now preface the present stage by a diagram of the whole galaxy, Fig. 14. This diagram was made under the direction of Dr. J. S. Plaskett, director of the Dominion Astrophysical Observatory at Victoria, for his Halley lecture on "The Dimensions and Structure of the Galaxy." It shows the galaxy as we think it might appear when seen edge-on from the outside. At right angles to the present view we should expect to see a great spiral structure with a bright central nucleus, as we actually

Mount Wilson Observatory.

FIG. 22. ANOTHER PHOTOGRAPH OF ILLUMINATED MATERIAL IN OUR OWN GALAXY.

shall see later on, in photographs of spiral nebulae or other galaxies that lie outside our own.

Just as it is hard "to see the forest because of the trees," so it is very difficult to study the structure of our own galaxy from a place inside it. Nevertheless, there is nothing in this diagram in serious contradiction with our present knowledge. The dark line down the center represents—with perhaps too regular an outline—a layer of absorbing dust for which we shall later see evidence. And it is dust such as this which presumably prevents us from seeing the bright central nucleus of our own galaxy. The location of the sun, with the earth and other planets, is indicated by a label well to the left of the center of the galaxy. The smaller dots, outside the sharper limits of the galaxy, represent individual stars with a gradually decreasing density of distribution as we get further and further away; and the larger dots represent globular clusters of stars which were first used at Mount Wilson by Shapley in studying the shape and size of the galaxy.

The diameter of the galaxy is of course enormous, but may now be set with some accuracy at about 30,000 parsecs or 100,000 light years. To give an idea of what this figure means, it will be remembered that light travels 186,000 miles a second. It takes eight minutes for light to travel from the sun to the earth, one hour and 20 minutes from the sun to Saturn, the furthest planet known to the ancients, five hours and 30 minutes to Pluto, the most distant planet now known, 4.3 years from the sun to the nearest star Proxima, 8.8 years from the sun to the brightest star Sirius, but 100,000 years to travel the length of the galaxy.

I next wish to show you some actual photographs of objects inside the galaxy. First and most important of all come of course the stars themselves, numbering, according to the estimate of Seares, of Mount Wilson, somewhere around thirty thousand million for the galaxy as a whole. Unfortunately the stars do not give imposing pictures, since no star is near enough and big enough to produce more than an unresolved point of light, even with the most powerful telescope. Perhaps the best I can do is to show (Fig. 15) two photographs, made five years apart by Barnard at the Yerkes Observatory, of the triple star Krüger 60, showing in the five years a small rotation of the closest pair around their common center of gravity. The size of image in such a picture is determined by the brightness of the star itself through the effect of "photographic spreading."

Photographs of groups of stars are much more interesting. Fig. 16 gives two different exposures of a so-called open cluster of stars (Messier 35); in Fig. 17 we have some great clouds of stars in the constellation Sagittarius; and in Fig. 18 a globular cluster of stars (Messier 3), the kind of object already mentioned as used in outlining the galaxy.

In addition to the stars themselves we can also find great masses of gas and dust in the galaxy, and when these are totally or partially illuminated by a nearby star the result can be very striking. Figs. 19, 20, 21 and 22 give four quite different examples of such illuminated stuff, Fig. 21 showing the appearance in 1922, 1926 and 1931 of the expanding ring of material shot off by the explosion of Nova Aquilae in 1918.

(To be concluded in the January issue)

THE RELATION OF ORGANISMS TO THE SALTS OF THE OCEAN

By Dr. LAURENCE IRVING

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MAN and other animals congregate along the borders of the sea, where they can find their prey in the life which is so abundant there. Along the shores the conditions for life seem to be well fulfilled, for tides and waves, varying with the time and weather, present in the constantly changing environment an opportunity for each organism to choose its favorable conditions. It is this area of transition from land to sea that typifies the sea for most of us and which gives us the idea that to change is the most striking characteristic of the sea.

But these changes in the sea are largely superficial and littoral, and their impressiveness depends mainly upon the point of view or upon the personal motives of the observer. The occasional voyager is inclined to view with concern the disturbance which is effected by the superficial movements of the sea upon sensations which are adjusted to his usual firm base on solid land. But for the practiced mariner, the only uncertainty about the sea rests in the accuracy of his own calculations.

The sea is the regulator of temperature and humidity along the coasts, where climate is always moderated by the tempering effects of nearby large masses of water, and for animals that live in the sea, environmental conditions are relatively constant. Imagine the simplicity of existence for a mammal like the seal, in spite of the fact that as a mammal it still exists relatively as an alien in the marine environment. There are no diurnal changes of temperature. Even the seasonal changes are small, and practically they are evaded by simple and sensible migratory habits. The effect of gravity is unimportant for an animal living in a medium which has the same specific gravity as its own body. No hills nor valleys interfere with locomotion, and movement in three dimensions is easier than it is for us in two. In fact, considering the comfortable appearance of the seal, it would seem that part of its expression of satisfaction is derived from the realization that its ancestors wisely recognized their error in competing for a variable terrestrial habitat and reverted to the relatively uncontested and practically uniform environmental conditions which prevail in the sea.

Although the sea is more uniform than the land in certain physical characteristics, it is even less variable in its chemical properties. The sea is a saline solution, which contains on the average about 3.4 grams of salt in each 100 cubic centimeters of water. Certain circumscribed areas, like the Baltic, may be diluted by the fresh water which runs in; or other areas, like the Red Sea, may be concentrated by the hot dry climate to which they are exposed. But the greatest part of the sea is uniform in concentration.

The salt which is contained in sea water is not common salt, or sodium chloride, alone, as can be recognized from the bitter taste of sea water. In addition to sodium chloride, which forms 85 per cent. of the salt, the sea contains at least traces of about half of the elements. Seven of these constituents make up 99.8 per cent. of the dissolved material, as is shown in Table 1, and these are always present in the same proportions in all parts of the sea. The dilution which occurs near large watersheds or the slight concentration in the dry tropics scarcely alters the composition of the marine salts so that the result is detectible. This fact was put forward as the result of the careful and judicious

TABLE 1
THE COMPOSITION OF SALTS OF THE OCEAN*

	Per cent. of total dissolved matter
Cl	55.3
Na	30.6
SO_4	7.7
Mg	3.7
Ca	1.2
K	1.1
CO_3	0.2
Total	99.8

* Tabulated by Clarke (1924) from Dittmar's analyses.

analyses made by Dittmar[1] on samples collected during the famous expedition of H.M.S. *Challenger*. These results summarize one of the finest series of analyses which have ever been performed, and their significance is a tribute to the judicious choice of methods on the part of the analyst and to the scrupulous care with which the analyses were executed and described. Subsequent analyses have only confirmed the results and conclusions of Dittmar.

The composition of marine salts is uniform throughout the entire volume of the ocean. The ocean can then be regarded as a single salt solution of known composition. The volume of this solution entitles it to special consideration because it is probably the largest homogeneous mass of material in the universe which can be defined in terms of a number of common and familiar components. Any generalization which can be made upon a mass of such size is also biologically significant, because the ocean constitutes a well-populated environment of organic life.

Marine animals and plants are quite sensitive to the salt composition of the water in which they live. This sensitivity is observed in the effects which salts of calcium and potassium exert upon the heart beat, the excitation of muscle and nerve, permeability and penetration of cellular and tissue membranes and visible changes in protoplasmic structures. And definitely related to this sensitivity is the discrimination which marine organisms exercise in selecting from among the marine salts only certain ones of the constituents which they incorporate in their protoplasm. It is this relation between the mineral composition of marine organisms and the ocean salts which we wish to consider more carefully.

A favorite method of approach to the description of the environmental conditions which now exist is to search through their history toward their origins. The composition of the sea is now uniform throughout its spatial dimensions. Although the change is not rapid, the sea has nevertheless gradually become a more concentrated solution of salts during the time which has left geological records. The simplest view of the origin of the sea is that it was originally a body of water which was either nearly fresh or at least much less salty than it is to-day. Slow erosion of the rocks dissolved them and eventually transported the soluble salts to the sea, where evaporation of water left behind the salts in a solution which steadily became more concentrated. The original surface of the earth was covered with igneous rocks, and it was from the eroded products of these igneous rocks that the marine salts were ultimately derived.

As an initial step in our search for the origin of the marine salts, we can compare (Table 2) the relative abundance of the components of the marine salts and of the igneous rocks. The comparison is not very good, for the substances which make up 99.8 per cent. of the ocean

TABLE 2
AVERAGE COMPOSITION OF IGNEOUS ROCKS AND OF THE OCEAN SALTS*

	Igneous rocks Per cent.	Ocean salts Per cent.
Cl	0.06	55.3
Na	2.50	30.6
SO_4	0.10	7.7
Mg	2.29	3.7
Ca	3.47	1.2
K	2.47	1.1
Total	10.89	99.6

* From Clarke, 1924, p. 29.

[1] W. Dittmar, "Report on the Voyage of H.M.S. *Challenger* 1873–76.—"Physics and Chemistry," Vol. 1, 1884.

salts only amount to 10.89 per cent. of the igneous rocks. A further objection to the view that igneous rocks are the source of marine salts is the fact that these constituents are quite different in the relative abundance in which they occur; for in the ocean salts the substances are in order of decreasing proportion

$$Cl > Na > SO_4 > Mg > Ca > K.$$

while in the igneous rocks, the order is partly reversed, and

$$Ca > Na = K > Mg > SO_4 > Cl.$$

After all, it is apparent that much of the eroded material derived from igneous rocks was simply disintegrated and transported by streams to nearby valleys, with the result that only a fraction of the components of the igneous rocks was ever dissolved and transported for any great distance toward the sea. But among the elements which are common to the igneous rocks and the sea there has been a process of selection which has acted to preserve in solution chloride and concentrate sodium, while potassium and calcium have been lost. This view is made more reasonable by the fact that calcium and potassium are more abundant in the sedimentary rocks than chlorides and sodium, the latter two being in fact rather rarely deposited.[2]

It is a reasonable view to suggest that the marine salts were derived from the igneous rocks, but such a wide gap in time has intervened, and the sedimentary rocks which were removed are so dispersed and various that there is no profit in going beyond this suggestion of the remote relation which exists. A closer precursor of the marine salts can be seen in the dissolved material which the rivers bring to the sea. There is a good example of the recent formation of a salt lake in the Salton Sea, which was made in 1906 when the Colorado River overflowed into the Imperial Valley. But it is not a good analogy for the development of salinity in the ocean, for the salt was derived from saline material in the soil rather than by concentration of the salt in the river water. The other saline lakes are equally poor models, for they have usually been found in the basins of still older lakes which had become saline and deposited their salt as they dried up. The present salt lakes are for the most part only the re-solution of these earlier deposits.

The ocean is unique as a body of salt water. But it is easy to infer the development of its salinity from the course of present events. The rivers annually bring to the sea a large amount of dissolved material. As the water of the sea evaporates it leaves behind the salt, and this process of chemical denudation and concentration must have occurred for as long a time as water has been condensed upon the land and evaporated from the sea. The processes of chemical denudation have long been appreciated and carefully examined. The waters of all the rivers have been analyzed and their present annual contributions to the ocean salts have been compiled by F. W. Clarke.[3] These figures are listed in Table 3.

TABLE 3
COMPARISON OF OCEANIC AND FLUVIATILE SALTS

	Annual from rivers (metric tons × 10^9)	In ocean (metric tons × 10^{12})
CO_3 ...	961.350	95.6
SO_4 ...	332.030	3,553.0
Cl	155.350	25,538.0
Na	158.357	14,130.0
K	57.982	510.8
Ca	557.670	552.8
Mg	93.264	1,721.0

When the ocean salts and the fluviatile salts are compared, it is plain that their compositions are quite different. In the ocean salts the components are, in diminishing order of abundance,

$$Cl > Na > SO_4 > Mg > Ca > K > CO_3$$

whereas in the fluviatile salts, the order is

$$CO_3 > Ca > SO_4 > Na > Cl > Mg > K.$$

In some respects the positions are quite reversed, and if we are to regard the

[2] F. W. Clarke, U. S. Geol. Survey Bull., 770, 1924.

[3] *Ibid.*, p. 138.

fluviatile salts as the source of the ocean salts, then some process of selection must have selectively precipitated calcium and the carbonates from the river salts, while it has precipitated the chlorides and sodium to a much smaller degree.

The view that the salts of the ocean originated by concentration of the salts which are brought in by the river waters has been commonly advanced. Proceeding on the basis of that assumption, a simple calculation provides an estimate of the age of the ocean.[4] If the total amount of a substance in the sea be divided by the annual contribution of all the rivers, the quotient will indicate the age of the ocean. This procedure has been frequently followed, choosing by preference the element sodium as an indicator. The net result of the calculation indicates that the ocean is about 90,000,000 years old. A number of corrections for this figure have been carefully reviewed by Clarke.[5] They include an allowance for the fact that the earth's surface, which was originally covered with igneous rocks, is now about three quarters covered by sedimentary rocks, with the probability that in former times the sodium content of the rivers was greater than it is at present. These corrections would still leave the age of the ocean at about 70,000,000 years, which is apparently consistent with the duration of other geological processes.

Suppose we were to attempt an estimate of the age of the ocean on the basis of the time required for the rivers to supply to the sea the other substances beside sodium. This has been done in Table 4, and the results are not at all concordant. It is not our particular problem to estimate the age of the ocean and we will accept the geologists' figure, which is consistent with the steady accumulation of sodium. But the disagreement suggests that the sea has treated each component of river water in different fashion. In several conspicuous instances the differential treatment appears to be the result of organic activity, and we are selecting these cases in order to demonstrate the significant relation of organisms to the mineral composition of the sea.

TABLE 4

CALCULATIONS OF AGE OF OCEAN (WITHOUT CORRECTIONS)

CO_3	$\frac{95.6 \times 10^{12}}{961.350 \times 10^{3}}$	$= \frac{95 \times 10^{12}}{96 \times 10^{7}}$	$= 10^{8}$
Ca	$\frac{553 \times 10^{12}}{557.670 \times 10^{3}}$	$= \frac{55 \times 10^{13}}{56 \times 10^{7}}$	$= 10^{8}$
K	$\frac{510 \times 10^{12}}{57982 \times 10^{3}}$	$= \frac{51 \times 10^{13}}{58 \times 10^{6}}$	$= .88 \times 10^{7}$
SO_4	$\frac{3553 \times 10^{12}}{332.030 \times 10^{3}}$	$= \frac{36 \times 10^{14}}{33 \times 10^{7}}$	$= 10^{7}$
Mg	$\frac{1721 \times 10^{12}}{93264 \times 10^{3}}$	$= \frac{17 \times 10^{14}}{93 \times 10^{6}}$	$= .18 \times 10^{8}$
Na	$\frac{14.130 \times 10^{12}}{158.357 \times 10^{3}}$	$= \frac{14 \times 10^{15}}{16 \times 10^{7}}$	$= .8 \times 9 \times 10^{8}$
Cl	$\frac{25.538 \times 10^{12}}{155.350 \times 10^{3}}$	$= \frac{26 \times 10^{15}}{16 \times 10^{7}}$	$= 1.6 \times 10^{8}$

Let us regard the results in the order of those which give the largest quotient and so suggest the greatest age of the ocean. On the basis of chlorine, the quotient is too great, and it is suggested that some chloride was originally present in the waters of the sea.[6] It is not likely that considerable quantities of either sodium or chlorides have been precipitated, for they do not occur in more than traces in most of the sedimentary deposits. Since no considerable deposits of chloride have been discovered the inconsistency in regard to chlorine can not be attributed to selective precipitation.

The quotient for magnesium suggests an age of less than 20 million years. If magnesium had been precipitated more rapidly than sodium, the result would be explained. Sedimentary deposits containing magnesium salts are well known. Many organisms fix small quantities of magnesium in their shells or skeletons, and the corallines contain magnesium

[4] *Ibid.*, p. 150.
[5] *Ibid.*, p. 154.
[6] *Ibid.*, p. 142.

next in abundance to calcium. It is certain that a considerable quantity of magnesium has been precipitated by organisms, but it is difficult to account for the dolomites and other magnesium deposits on the basis of organic activity alone. The fact but not the extent of magnesium precipitation by organisms is evident.

The result of the calculation on the basis of sulfate comes next in order. Following the implication that a small quotient signifies more rapid precipitation, there should be evidence in the sulfur-containing deposits. It is not available in quantitative terms, but deposits of sulfur, sulfates and sulfides of non-igneous origin are quite common. Sulfur is an element which is easily oxidized or reduced and which forms many compounds. It is an element upon which the sulfur bacteria depend and which they precipitate actively as sulfur. In fact, it is extensively utilized by all organisms as sulfides. The organic traffic in sulfur is so impressive and it proceeds so frequently toward the formation of reduced sulfur from the soluble, oxidized form that we can easily believe that the metabolic reduction of sulfates has fixed large quantities. Such a process of organic precipitation may well have prevented sulfates from accumulating in the sea as rapidly as the rivers brought them in.

In the case of potassium the sediments contain notably larger proportions than sodium,[7] and the precipitated potassium is located in these deposits. Whether the amounts are of the right magnitude to strike a balance is a question. But it is conspicuous that organisms contain more potassium than sodium. Offhand it would seem as if sodium chloride were the principal mineral component of the animal for the simple reason that we are accustomed to add pure sodium chloride to our food. But the sodium chloride is ingested and promptly excreted, apparently filling its rôle in the rapidity and ease with which it is transported through the body. No appreciable amount appears to be fixed, and it is doubtful whether any of it even enters in any permanent sense into the composition of the cell.[8] Potassium, on the other hand, is more essentially a true cellular component, and it is quite possible that its more intimate incorporation into cellular substances had contributed to its removal from the river salts as they have become concentrated in the ocean.

Calcium and carbonate are the principal components of fluviatile salts, but they are minor components of the ocean. Their removal must have been proceeding at the most rapid rate of all the substances considered. It is also possible to see the precipitated calcium carbonate in the extensive sedimentary deposits. As their fossil structure shows, these are nearly all of obvious organic origin. And at the present time the process of calcium carbonate precipitation proceeds conspicuously in the rapid formation of shells and skeletons.

It might be objected that it is unwarranted to suppose that the conditions seen in the rivers and ocean to-day represent a fair sample of the preceding 100,000,000 years. It is a desperate attempt to extrapolate from a few current years back to a position which is relatively so remote on the curve as is the supposed origin of the ocean. But it is not outright extrapolation of a long curve from a point. For there is no reason for believing in the occurrence of major natural cataclysms, and it would be assuming a cataclysmic change to say that the proportions of sodium chloride and calcium carbonate in the ocean originated directly from the rivers. But that argument has not much positive bearing upon the necessary course of evolution of the oceanic salts. It is certainly impressive, however, that the substances which would need to be abstracted from the fluviatile salts in the course of their

[7] *Ibid.*, p. 140.

[8] L. Irving and J. F. Mauery, *Biol. Rev.*, 11: 287, 1936.

conversion into marine salts can be seen in the sedimentary deposits in abundance corresponding to the precipitation which the hypothesis would require. It is also important to consider that organic processes of fixation select the components according to the extent of their precipitation.

The organic processes which remove minerals are selective. They do not take elements according to their abundance in the environment but according to some peculiar criterion of the organism itself. It may be that the criterion for the selection of a substance depends upon its chemical properties, and the discrimination which is shown toward magnesium and calcium seem to offer good example. Calcium carbonate is only sparingly soluble in sea water, and the sea is probably nearly saturated with calcium carbonate.[9,10] If carbon dioxide is removed by photosynthesis, calcium carbonate is precipitated, a process which rapidly forms visible encrustations upon filaments of certain algae. Magnesium is an element which is similar to calcium in many respects, but it can not be precipitated by the photosynthetic removal of carbon dioxide, nor by any conditions which are naturally attained in sea water.[11,12,13] From these considerations one might say that chemical properties have determined the favor which organisms show in selecting calcium carbonate in the formation of shells, and the fact that magnesium is only a rare component of shells and skeletons.

The distinction is, although interesting, not particularly useful in showing how organisms make their selection. For naturally they can only accomplish chemical reactions which are possible, and if the conditions necessary for the formation of a precipitate are inconsistent with the life of the protoplasm, then the precipitate will not be formed. The significant part of the precipitation exists in the operation which locally affects the solubility of that substance so that it will be precipitated. And in order to secure the conditions for precipitation the organism must modify its environment. Animals and plants can and do precipitate calcium carbonate very rapidly, but in doing so they must work to modify the sea water locally so that the substance becomes insoluble.

Such a reaction as the precipitation of calcium carbonate is reversible, and one might expect that in the sea or in tissues the precipitates would be dissolved again as readily as they were first formed. The precipitation is not, however, reversible in practice; for the first step in precipitation is for the precipitating substances to make contact with each other, and they are highly mobile while they are in solution. Once the precipitation has occurred, the mobility of the substance decreases, and the aggregation of precipitated particles further reduces the probability of contact with the dissolving agent. It is in this way that precipitates which are formed locally by organic activity will not quickly become dissolved again, even though they are in contact with an unsaturated solution. The reversal of precipitation by resolution is qualified by such differences in velocity of the two processes that the reaction proceeds more rapidly toward precipitation.

It has been suggested that the reasons for the selection by organisms of certain mineral constituents and the exclusion of others may be referred to the differences in their chemical properties. The precipitation of $CaCO_3$ is easily accomplished, but magnesium carbonate is soluble under conditions which organisms can produce. Another example is

[9] J. Johnston and E. D. Williamson, *Jour. Geol.*, 24: 729, 1916.

[10] H. Wattenberg, *Annalen d. Hydrographie u. maritimen Meteorologie*, 59: 273, 1931.

[11] A. R. Haas, *Jour. Biol. Chem.*, 26: 515, 1916.

[12] W. R. G. Atkins, *Jour. Marine Biol. Ass'n. United Kingdom*, 12: 717, 1922.

[13] L. Irving, *Jour. Marine Biol. Ass'n. United Kingdom*, 1926.

seen in sodium chloride, which forms no natural organic compounds; nor does it enter into the processes of intermediary metabolism. It occurs in organisms in simple solution as a soluble salt, and no organic reaction renders it insoluble. But the statement of these differences according to chemical properties is simply another qualitative statement of the facts and does not particularly indicate how living organisms operate upon their lifeless environment.

The most interesting relation appears in the fact that organisms select substances from their environment in an active manner. Either they move about and on more or less random encounters pick and choose what they will admit: or else admitting all dissolved constituents, they excrete some and retain the others. This selection from the environment is one of the principal activities of organisms, and toward its execution they devote practically all their energy. Animals and plants dispose of a very considerable amount of energy, and a large part of it is applied toward modification of the chemical composition of the environment according to their own inherent organic plan. This plan is remarkably uniform, for the different forms of animals and plants display a surprisingly conservative and uniform pattern of chemical activity. The result is that all organisms are applying a large part of their energy to the selection and fixation of a few elements which fit the chemical pattern of their substance.

Just how great is the amount of energy which organisms expend in modifying the chemical composition of their environment? The answer is not numerical but relative, for in the sea, organic reactions are the only ones which can produce appreciable changes in chemical composition. The changes in temperature which occur in the sea are of insignificant influence in altering chemical composition. Currents and movement of water may aid in mixing or separating components, but their influence is not directly visible. The light of the sun is only appreciably effective when applied through the means of photosynthesis. In fact, one may believe that no significant exothermic chemical reactions would occur in the sea without the intervention of organisms. Through them, however, solar energy is constantly applied to the selective precipitation of some elements, and equally important from the view-point of selection from the environment, to the utilization of others without permanently withdrawing them.

From these observations we could say that organisms have been constantly at work fixing some elements and discarding others. They fix calcium carbonate practically irreversibly: they fix some potassium and sulfur and magnesium, while they pass sodium chloride through their tissues as a transient mineral component which is never fixed. Thus the chemical pattern of organisms supplies the discrimination which would modify the fluviatile salts toward the composition of ocean salts, and organisms constitute the only significant agent for such a change which can dispose of the energy necessary for its accomplishment.

If we were to state the relation between the chemical composition of the sea in terms of cause and effect, we should say that the environment is the product of the organism rather than the reverse. Such a simplification of the case involves an assumption of the validity of the idea of significant causality, and to discuss the subject is to impose too great a burden upon a line of argument which has been developed in order to show that organisms have an inherent discriminating preference for certain elements and that they dispose of the energy necessary to make the selection. In conclusion, I will leave the proposition that only organic processes can have applied the energy which has brought the composition of the sea to its present condition.

THE CONTRIBUTION OF CHOLERA TO PUBLIC HEALTH

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LIKE glaciation, floods and famine, disease makes man active, versatile and inventive by shattering his complacency, rendering him supremely uncomfortable, developing his foresight and forcing him to assume some responsibility for his own destiny. Pestilence destroys equanimity and teaches that procrastination is death, action is life, and knowledge is salvation. Under its influence, men think, defy superstition, ignore tradition, and try the new.

Diseases which do most for public welfare strike suddenly, kill quickly, destroy commerce, and cause panics. This fact is clearly seen by comparison. Tuberculosis has contributed a great deal to preventive medicine, hospitalization and public health, but its lack of impact, spectacle and catastrophic effects permits an emotional tolerance where 100,000 deaths from it cause less national excitement than one man trapped in a cave.

Not so with leprosy, yellow fever, virulent smallpox, bubonic plague and cholera—they command respect, insist upon action, and get results. With industry demoralized, business paralyzed, and the death-roll increasing from day to day, the anti-vaccinationist goes to the doctor or to the cemetery, the obstructionist is cast aside, and a thoroughly aroused public demands effective measures of control, makes appropriations to support them, and enacts laws to give them police power.

Leprosy stimulated and developed ancient preventive medicine; bubonic plague was the great activator of mediæval hygiene. The former gave rise to isolation; the latter, to quarantine. What these scourges were to the Ancients and to the Middle Ages in the development of public health, cholera is to the modern sanitation of cities and industrial centers in the nineteenth century.

Cholera has been peculiarly persuasive, persistent and successful in its promotion of sanitation. If the public health work it stimulated became highly efficient and by prevention of disease destroyed the obvious reasons for its own continuance and people became indifferent and permitted it to cease for want of support, cholera had pandemics follow pandemics until the dullest nation was unable to forget the disasters it had suffered. Civilization is forever its debtor.

CHOLERA BEGINS ITS WORLD-WIDE MISSION

Just when the comma bacillus first became parasitic for man, like the origin of life on the earth, is still a biological mystery. The disease known as cholera was described by the Ancient Chinese and Hindus. Hippocrates, the father of medicine and the famous physician of the Periclean age, gives considerable details concerning the history and symptoms of the disease. Aretoeus and Celsus were both familiar with it. Cholera has existed in India for many centuries in about the same form as at present. It appeared in the Portuguese settlement of Goa as early as 1543 and in the French district of Pondicherry in 1768.

Armies have ever been the servant of pestilence. European invasions of India, England's opening up of Hindustan to the commerce of Western Asia and

Europe, and India's fostering of trade with the Dutch Indies spread the disease. Cholera held to the routes of armies engaged in war, followed caravans and crossed the sea to nearby islands. Fairs, religious festivals and pilgrimages repeatedly brought crowds together, introduced the disease, and started pandemics which had repercussions even in remote countries.

Of ten such pandemics since 1817, six went by land through Afghanistan or Persia and thence through the Caucasus and Transcaspia to Russia and Western Europe; four took the route via the Red Sea and Egypt and reached the Mediterranean basin by land and by sea. In 1832, cholera embarked from Ireland for Canada and on the eighth of June appeared in a boarding house for immigrants in Quebec. Thirty-six hours later by boat the disease had reached Montreal, 200 miles distant.

Forwarding of immigrants quickly brought the disease to Kingston, Toronto and Niagara. It reached Detroit by similar means and proceeded west along the Great Lakes. At Fort Dearborn, out of one thousand men, over two hundred cases were admitted to the hospital in a week. In September, it was attacking the military posts on the Upper Mississippi. In the meantime, an immigrant ship had started a new conflagration at New York which extended up the Hudson and to Philadelphia and thence westward. In 1833, cholera entered the Gulf ports from Cuba, traveled up the Mississippi and Ohio Rivers and into the interior. It spread over the whole country during 1835–36 and then subsided for nearly ten years.

In 1846, the disease was again on the move. It crossed the Atlantic and started epidemics in both New York and New Orleans. In the two succeeding years it spread from the Atlantic to the Pacific and from Canada to the Gulf. It overtook the "forty-niners" in their covered wagons on the western plains and pursued the gold seekers bound for California via the Isthmus of Darien. Business was interrupted, opening up of the West delayed, and the development of the country retarded.

The fourth pandemic of cholera is said to have originated in the festival of Hardwar in 1865 and to have subsided in the Mississippi Valley in 1873. It seems to have reached the United States from Bombay via Mecca, Marseilles and Havre. On October 12 the *Atalanta* arrived in New York from Havre after having had 102 cases and 23 deaths in passage. Cholera spread along the great intra-national highways of trade and travel and caused a deplorable mortality, especially in the Mississippi Valley. No organized effort was made to prevent the importation of the disease and little done to prevent its extension.

But this pandemic gave a demonstration the public was not likely to forget. It taught with terrible emphasis the necessity of sanitation, the danger of procrastination and the cost of indifference. Cholera has reached our seaboards a number of times since but has been promptly refused admission; if it has slipped through a port of entry, it has immediately been brought under control and eradicated.

Impressive Health Education

As a teacher of sanitation and public health, the vibrio of cholera is effective beyond the reach of skill. It is dramatic in its demonstrations, and is deadly practical. So well did its instruction carry over into life that even a rumor of its approach caused houses to be cleansed, streets washed, marts of trade to become panicky, and citizens to flee their homes.

Its technique and methods have been described by Heinrich Heine with the gift of a literary genius. A masked ball is on in Paris, the dance is in full swing, brave men and fair ladies move to the rhythm of music, and joy is unconfined.

Suddenly the gayest of the harlequins collapses, cold in limbs, and under the mask "violet blue" in the face. Laughter dies out, dancing ceases, and in a short while carriage loads of people are being hurried from the redoubt to the Hotel Dieu to die. To prevent a panic among the patients, the dead are thrust into rude graves in their dominoes. Soon public halls are filled with corpses sewed in sacks for want of coffins. Long lines of hearses stand outside of Pére Lachaise. The rich gather up their belongings and flee the town. Over 120,000 passports are issued at the Hotel de Ville. A guillotine ambulante is stalking abroad, and its effects duplicate the scenes of the Revolution or the plague of Milan.

John B. Rauch, secretary of the Illinois State Board of Health, in his masterly address at the opening of the National Conference of State Boards of Health at St. Louis in October, 1884, in urging the provision of facilities to combat cholera in the United States no less clearly indicated its terrible effects when he pointed out that "This means more than the good to be found in the saving of human life and in avoiding the suffering and misery, the ruined homes, and desolated families which an epidemic always leaves in its track. It means the prevention of panics; it means the prevention of the loss of trade and commerce; it means the prevention of the loss of millions of dollars, all of which would inevitably result from an epidemic of Asiatic cholera in this country. Already the disease has cost southern Europe not less than one hundred million dollars—six million dollars up to October first in trying to prevent its spread in Italy alone—with a loss of four million dollars even in the month of August before the disease had effected a serious foothold; and now it is announced that the decrease of the national revenues of France has been materially aggravated by the reduction from the receipts from railways caused by the cessation of travel consequent upon the prevalence of the cholera epidemic. And yet Europe is only upon the threshold of this epidemic.

"Let us push sanitation by every means in our power, and to the fullest extent . . . in the knowledge that every sanitary reform tells permanently and continuously on the whole body of preventable diseases; and to the extent of such reforms are the conditions made more favorable for the prevention of all epidemics. No comparison is possible between the cost of suppression and the cost of an epidemic. . . . Who shall place a dollar-and-cents value on the lives which would be sacrificed, and the suffering entailed by an epidemic of Asiatic cholera? Shall we wait until the pestilence has landed and obtained a foothold? A single outbreak, possibly a single case, in New York, Chicago, St. Louis, or New Orleans would cost the country millions of dollars." (Shrinkage in the provision market).

Cholera has not been an unmitigated evil. It compelled men to think, to learn and to act. Out of their terrible experience came better living conditions, broader sympathies, greater tolerance and a sense of social responsibility which had tremendous possibilities for the future. Men took inventories of themselves and their communities, caught a vision of opportunities for progress, and moved forward.

Even an unsentimental mandarin, when urged by Russian authorities to adopt preventive measures against cholera, showed that he apprehended its potentialities for good when he replied that "the deaths would allow more room in the world for those who survived, and besides, that cholera chose its victims from the filthy and the intemperate and that no person of courage, who lived with moderation and cleanliness would die of it." Obviously, he lived before the era of bacteriology and was a near-sighted observer.

"A Former Surgeon-General in the

Service of the Honorable East India Company" as early as 1866 understood that "epidemic cholera, like the plague and yellow fever, is a main branch of the Universal Sanitary Commission of Almighty God—armed with Herculean power to turn a river of death through the Augean stables of the world's filth and lewdness and drunkenness and ignorance and waste; and in the name of the King of Terrors to compel from purple and fine linen and sumptuous fare a trembling recognition of their mortal brotherhood with nakedness and starvation and pitiful squalor." In beautiful language he anticipated the modern discovery that bacteria are great social climbers.

When cholera appears, the enlightened world demands action. The voices of ignorance, tradition and procrastination are lost in the loud insistence that science be used to prevent a catastrophe. Through international conferences, maritime regulations and quarantine have been instituted and detention hospitals provided. By the use of visés the routes of pilgrims are now being determined and their vaccination against smallpox and cholera are required. Sanitation has been improved on land and sea. Suffering has given rise to knowledge and progress has been wrung from disaster.

Although cholera is still a major menace in certain parts of the world, it is not likely to be seen again as a pandemic originating in Hardwar or Mecca and spending itself in the Mississippi Valley. When a million pilgrims can camp around Allahabad in 1930 without the occurrence of a single case of cholera, contributions of this disease to sanitation have become invaluable. With proper precautions the Faithful can visit their shrines in safety and business may proceed as usual.

Personal Hygiene

In a disease as sudden in its onset and as devastating in its effects as cholera, it is not surprising that speculations concerning its nature should be numerous and procedures for its control should be varied. They cover almost the entire field of personal hygiene and are potent factors in the general promotion of health.

Nearly twenty years before the discovery of the vibrio of cholera, Montgomery of Madras warned against "the vicissitudes of climate"—sudden chilling of air and tropical suns—dry months and rainy seasons. He attached importance to physical fatigue and nervous depression as predisposing causes and was convinced that both were markedly effective in individuals proceeding on long journeys or in soldiers on the march. His observations were correct, but the greater liability to attack was primarily due to increased opportunities for becoming infected and only secondarily to lowered resistance caused by exhaustion.

Excess in eating, drinking and venery were thought to be conducive to the disease. "Undue abstinence or deprivation of food or the presence of injurious properties in it" were to be avoided. The evils of overcrowding were recognized and vitiated air was considered "fatally morbific." Lowered vitality from whatever cause will favor the growth of the vibrio of cholera and also decreases the resistance to other diseases.

"The cholera poison" was known to affect "with equal virulence" bedding and towels so that the soiled linen of a patient could spread the disease over a whole district. "Foul skins" and the clothing of the "great unwashed" were thought to create an atmosphere in which dirt might quickly be converted into "a nucleus of cholera poison." This view led to the advice that particular attention should be given to personal cleanliness by daily bathing and was most likely an important factor in overcoming the prejudice against bathtubs and in the repealing of the laws against them in many cities and states in this country.

Sanitation

No fact of history is more astounding than man's tolerance for filth—his contentment with dirty milk, his use of water contaminated with excreta and the disposal of refuse and his discharges in a way to spoil the landscape and to pollute his food. For centuries his esthetic sense was hopelessly dull, until cholera turned a stream of death into his sea of foulness. Then he began to think.

He conceived "that cholera discharges, if cast away without previous disinfection, may impart their own infective quality . . . to more innocent filth with which they mingle in drains or cesspools, and wherever else they flow or soak . . . thus poisoning . . . subsoil water. . . . If cholera poison . . . gets access even in small quantity to wells or other sources of drinking water, it will infect, in the most dangerous manner."

This conception, which has meant so much to water purification and sewage disposal, did not become a demonstrated conviction until Dr. John Snow in 1854 informed the vestrymen of St. James that the severe outbreak of cholera in London was caused by water from the Broad Street pump and that it would cease if its handle were removed. This it did. A subsequent survey of the well and its surroundings by York showed it to be contaminated by a cesspool which had received excreta from patients with cholera. The users of the well were drinking dilute sewage.

The classic lesson taught by cholera on the necessity of water purification and scientific sewage treatment in more modern times was given at Hamburg, Germany, in 1892. Both Hamburg and Altona, its virtual suburb, took their water supplies from the Elbe River. As Altona drew its water supply from the river below the outfall sewer of Hamburg, its water supply contained more sewage than did the Hamburg water. There was also another difference. Hamburg used the water untreated; Altona, after slow sand filtration. During August to October Russian emigrants were detained in crowded barracks on the bank of the Elbe while *en route* for America. Their sewage was discharged into the river. In a little over two months Hamburg, with a population of 640,000, had 17,000 cases of cholera, 8,605 deaths, and a death rate of 1,342 per hundred thousand population. Altona with a population of 143,000 had comparatively few cases and only 328 deaths. As many of the residents of Altona worked in Hamburg, it is not surprising that some of them contracted cholera.

Of extraordinary interest was the fact that in a certain portion of the towns the boundary line between them ran down the middle of the street. On one side the inhabitants received water from the supply of Altona; on the other, from that of Hamburg. The contrast was conclusive; the people of Hamburg experienced the epidemic; those of Altona escaped.

Robert Koch, the great German bacteriologist, thoroughly studied this epidemic and succeeded in isolating the spirillum of cholera from the polluted water of the Elbe River. He definitely proved that the disease was water-borne. To these crystal clear demonstrations of cholera, reinforced by equally impressive ones of typhoid fever, we owe a great deal for the development in this country of water purification, sewage treatment and rural sanitation.

When the cholera epidemic at Hamburg proved the effectiveness of slow sand filtration in purifying the water of Altona, it led to the use of similar protection for the Hamburg water supply and incidentally to the discovery of the fact that water purification not only produced a diminution in the death rates from cholera, typhoid fever and other intestinal diseases, but simultaneously caused a reduction in mortality rates

from non-intestinal diseases. This was noted by Dr. J. J. Reincke, health officer of Hamburg, and confirmed by Mills, Sedgwick and McNutt in this country. After carefully studying the problem, Hazen came to the conclusion that for every death saved from typhoid fever by the purification of water, there were three or four deaths saved from non-intestinal causes.

Subsequent investigations have raised questions as to the validity of the Mills-Reincke phenomenon and Hazen's theorem. But there is no doubt that a pure water supply diminishes the presence of cholera, diarrhea, dysentery and typhoid fever. It is also clear that the absence of intestinal diseases and their debilitating effects tend to insure the maintenance of individual resistance and thereby help to prevent the occurrence of other diseases like tuberculosis, pneumonia, etc. Thus cholera, aided by typhoid fever, compelled a sanitary triumph in an era of epochal discoveries.

Once it was clearly understood that cholera and typhoid fever were water-borne, sewage had to be disposed so as not to cause disease. As sewers were built to discharge their contents into the nearest body of water, difficulties ensued. If the stream receiving the sewage were small, a nuisance occurred, and litigation arose as to riparian rights and damages for pollution of the water; if untreated, the water supplies became infected, or shellfish contaminated, epidemics resulted, and legal action often followed. Modern sewage treatment is a great contribution of cholera and typhoid fever to public health.

Cleanliness and Disinfection

Cholera promoted cleanliness with a vengeance. It led to the adoption of extraordinary measures, which were even beyond the need of the occasion and often caused unnecessary expense. Streets were not only swept, but in many cities they were also washed and disinfected. Many of them were so foul that this vigorous cleansing changed their atmosphere, and facilitated transportation. The experience was novel; the example, overwhelming.

It was a general impression in Europe that although cholera could not be excluded by quarantine, it might be "stamped out" by disinfection. Thorough disinfection was declared to be the best means of protection against the disease. To individuals and communities threatened by cholera, thorough was the superlative.

Sewers were flushed with strong disinfectants, docks were cleaned, and nuisances were abated. Conditions likely to give rise to "mephitic vapors" and "poisonous gases" received special attention. Among outstanding dangers were sewers "which ran up-hill, and water closets, bathtubs, and stationary wash stands acting as ventilators for them." "In London in 1859, 20,000 pounds were expended in flushing the sewers with fresh water; and 110 tons of lime and 12 tons of chloride were thrown in every day at a weekly cost of 1,500 pounds." Some towns were rendered bankrupt by the thoroughness of their disinfection.

Sulphate of iron or copperas was considered the most efficient and potent. Carbolic acid and other coal tar preparations were second choice. Disinfectants were poured into the pipes of wash stands, bathtubs and water closets. Their outlets were closed with cotton at night because "it has been observed that when meat is exposed to air which has been passed through cotton, it will not putrefy for months."

Freshly prepared lime was used to disinfect outdoor privies. Solutions of chloride of lime were poured into sinks, soil pipes and other places from which offensive gases arose. House drains and cesspools were similarly treated. Sulfur was burned, goods fumigated and the premises were whitewashed. Soiled

linens were burned, and in Cairo rags were disinfected by boiling for four hours. Cholera's contribution to disinfection is large and important; the extra cleanliness it produced probably saved more lives from other filth diseases than the deaths it caused.

Quarantine

Cholera did not inaugurate quarantine but modified, amplified and gave it greater international significance. The use of isolation to control disease is almost as old as history. The ancient Hebrews employed it centuries before the Christian Era, and the sanitary code of the Pentateuch describes rather in detail procedures to make it effective. In 1374 the Venetian Republic excluded infected and suspected ships and made the first quarantine of infected areas in 1403, so-called because travelers from the Levant were isolated in a detention hospital for forty days. With the appearance of cholera, this measure was promptly used to control it.

However, it was found to be much less effective than had been anticipated. As a result, the impression soon became general in Europe that quarantine could not be relied upon to control cholera. It failed because carriers and mild cases were missed and passed into localities to start epidemics. With the discovery of the comma bacillus quarantine was placed on a sound scientific basis, and at present has a definite place in the control of cholera.

Highly fatal pandemics produce a harvest of fruit as well as a crop of tares. Cholera caused much sickness, misery and death. Under its mortal magic, hope of accomplishment gave place to a pervading sense of futility, and the enthusiasm of progress was overwhelmed by an appalling uncertainty. Civilization staggered from the shock of cholera and men wondered if another Dark Ages were at hand when bubonic plague wrecked empires and threatened man with extinction. Fatalism became dominant, moral idealism suffered a sag, and degeneration cast its ominous shadow across many lands of promise.

But cholera has had a brighter side! It gave terrible emphasis to the urgent need of sanitation—the necessity of pure drinking water, the proper treatment of sewage, a safe and adequate food supply, refuse disposal, better housing, cleanliness and an efficient organization to prevent and to control contagion. Its contributions to epidemiology are classics. The Broad Street well and the Hamburg epidemics will continue to teach generations yet to be born how intestinal diseases are spread. This scourge improved methods of disinfection and greatly increased the efficiency of notification of disease.

Cholera played a most significant rôle in the development of public health administration. Under its stimulation, maritime councils were created, quarantines established, immunization made obligatory, and suspected carriers of disease kept under surveillance. It motivated the calling of international conferences on sanitation and caused treaties to be made for the control of pestilence. Under its pressure, national health agencies came into being, legislative bodies assembled and laws were passed to promote health and to prevent disease. Through its influence boards of health were appointed, funds provided for their support, and commissions were set up whose reports mark the beginning of a new era in public welfare.

IN QUEST OF GORILLAS

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XIII. GORILLAS, MEN AND SLEEPING SICKNESS

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ON January ninth I stayed in camp and sent men out in several directions to look for gorillas. In each party were two men. In case they should come upon gorillas one man was immediately to return to camp for me, while the other man was to follow the gorillas, making a trail so that he could easily be followed when we arrived. They found no gorillas anywhere, so when they returned late in the afternoon I hunted to the east and south of camp.

On January eleventh I slept out in the forest listening for gorillas. I heard them call twice and saw many places where gorillas had fed a short time before. I returned to camp about 10:30 A.M., where I heard a palaver between Ngom and Ndongo about one of Ngom's wives. Ngom had been grouchy for three or four days; in fact, it seemed to me that nearly every one in camp was grouchy, but I did not know the reason. Finally this morning Ngom told me that Ndongo had taken one of his wives. Ndongo heard this and said: "Him lie. I no bin take dem woman."

"Him lie," Ngom replied. "Me bin talk for dem woman. Woman he agree. Ndongo no agree." He added furiously, "Ndongo he go pay," to which Ndongo replied, "Me no pay."

As Ngom was a chief he had a policeman at his orders and he threatened to have Ndongo taken to the French officials at Lomie and put in jail. Ndongo was my wash-boy and I did not want to lose him just then, nor did I want Ngom to take several days off to go to Lomie. I therefore told Ngom to let the matter rest until we returned to Djaposten, where we could talk the palaver, and he agreed to this.

However, there was still bad feeling, and finally the day came to move camp. Ngom sent for more porters, but when they arrived there was one man short and Ngom ordered his wife to carry the extra pack. I was busy packing up and getting the porters under way and at last all the loads were gone. Tsama had prepared a roasted plantain for my luncheon and I waited some little time for it to cool before I could eat it. Thus the others were far ahead when I started with Tsama and a head-man named Olen, who had two dogs he hoped to sell me. Following the trail toward Djaposten for about three miles in the heavy forest, we came upon Ngom standing beside his wife with a whip in his hand. The pack was lying on the ground. The woman was crying, and I could see a large welt across her back and a couple more on her thighs. As we approached, Ngom ordered her to put the pack on her head, but instead she started to cry again. Ngom was in a rage. He jumped at the woman and struck at her, but the switch broke. He took out his knife, cut a piece of liana hanging near by and struck her once with this before I could take it away from him. He said she was making a fuss just because there was a white

FERRY OVER THE NLONG.

FLOODED ROAD.

THE ROADS IN THE CAMEROUN ARE MADE WITH DEEP DITCHES ON EACH SIDE, AND LEMON GRASS IS PLANTED ALONG THEM, AS ITS MATTED ROOTS PREVENT THE WASHING AWAY OF THE SOIL.

MAP OF THE FRENCH CAMEROUN SHOWING THE LOCATION OF SOME OF THE PLACES MENTIONED IN THE TEXT.

man there. I told Tsama and Olen to put the pack on her head and we all moved on.

The next day I said to Ndongo: "Ngom he got police, he go take you for Lomie. *Chef-de-Poste* he go say, Ndongo he bad man, den he make you pay hundred franc. Police go make you sleep for ground den flog you plenty. Maybe police make you work for route. Dis palaver look bad plenty; Ndongo he better go pay Ngom just now, today." Ndongo said, "Ya, me go pay."

When Ngom came along I called him and said: "Maybe you go take Ndongo for Lomie. *Chef-de-Poste* go say, Ndongo be bad plenty for take dem woman. You go say, Monsieur *Chef-de-Poste*, you go make Ndongo pay hundred franc for me. Maybe *Chef-de-Poste* he go say, Ndongo take you woman, he pay hundred franc. Maybe Government take dem money, no give it for Ngom." Ngom replied: "Ndongo he bin take my woman, he go pay." I asked, "How much franc Ndongo go pay?" "Fifty franc (the equivalent of two dollars), he answered. Ndongo paid. The palaver was finished.

The following day when Ngom was about to leave for his house after visiting us, I saw him offer Ndongo a cigarette. Ndongo asked him to wait a minute and he would walk down to the village with him. In perfect peace they departed.

The routine of hunting continued

without much variation. We had slept in the forest several nights in order to listen for gorillas. On the night of January eleventh we slept near a little trail about three miles from camp. During the night I heard a gorilla talk only once, far away and to the north, in the direction Ngom said they had been feeding the day before. At 5:30 A.M. we had a severe electric storm with much thunder, lightning, wind and rain. Of course we were all wet through, as we had no shelter, sleeping on the ground, but we were not cold, for we managed to keep a good fire going. It was very dark in the forest until 7:00 o'clock. Olen, a chief of one of the villages of Djaposten, with the two dogs which I

DESERTED HUT BESIDE THE ROAD AT BILULU.
SECOND GROWTH FOREST HAS SWALLOWED UP THE REMAINS OF GARDENS.

hoped to use in hunting gorillas and chimpanzees, was with us at this time.

On the thirteenth of January Ngom, Nkoul, Olen and his two dogs and I hunted all day northeast of camp. We trailed a family of gorillas nearly half the day. Once Ngom and I got near enough to hear them when they crossed a palm swamp. The dogs were kept on rattans, so they were useless. We saw fresh elephant tracks, but in all the hunting we had not once had a chance to shoot an adult gorilla.

On the sixteenth of January we returned to Djaposten. The porters had found a rotten antelope which had been killed by a leopard and partly eaten.

A CHILD WITH SLEEPING SICKNESS. THIS CONDITION REPRESENTS THE FIRST STAGES OF TRYPANOSOMIASIS.

They took the remainder, but I warned them that I would look over every load when we arrived at Djaposten and if any load smelled of that meat, the porter would not be paid. It amused them very much when I sniffed the loads as they deposited them at Djaposten. I learned later that by agreement one man had carried all the antelope meat, while his load had been divided up among the others.

The day following my return to Djaposten a native brought me a live scaly ant-eater, of which I took some motion pictures. This animal was much more agile than the much larger East Indian pangolin.

On January twenty-first I went with Meyong to a little village about four miles from Djaposten, toward Lomie, to see a man of that village who was said to have killed many gorillas and chimpanzees. This man, Malong, and I hunted together all day toward the northeast, most of the time in second growth. I shot two large plantain-eaters and three monkeys, two with white on either side of the crown and one red-tailed. I also saw some large dark-colored monkeys with a white spot on the nose. On this hunt I found a very fine fungus, in form like a toadstool. The top was a flat disk with concentric growth rings. It was about eight inches in diameter, dark brown in color, with a stem about three eighths of an inch in diameter, also brown; the under side of the disk was cream-colored, not gilled like a mushroom but having a multitude of pores.

Malong was terribly scarred on his left breast, shoulder and arm, and had four deep scars in his back. I asked him how he received the wounds and was surprised to hear him say that they were made by a gorilla four or five years before. He said that at that time he had not attained his full growth, did not have a beard and did not know women.

I questioned him about it two or three times until I got the whole story. He had accompanied a party of rubber-gatherers into the forest. It was their habit not to get up very early in the morning, but he got up at dawn and hunted monkeys with his cross-bow, which shoots a tiny poisoned dart. He saw monkeys in second growth trees and was approaching them when suddenly he was confronted by a large male gorilla on the ground. It rushed at him, stopped, looked and then went off a short distance. Then it came on again and he turned to run. The gorilla grabbed for his buttocks, missed and caught his ankle. He struck the animal on the hand and in the face with the cross-bow and it again retreated a few paces and stood watching him. At this point a female gorilla came down from a near-by tree and the male rushed him again. He struck it in the face with his fist, all the time shouting for his friends to bring a knife, but they did not hear. The gorilla again retreated a few feet, looked at him and again came on, this time grabbing him by both ears and trying to bite his face, but he turned his head down. The gorilla was holding his right hand and tried to bite it, but he managed to jerk it out of his mouth, getting a nasty cut on the back of his wrist from the canine. The animal held him and bit his chest, shoulder and arm, but he finally struck it so that it released him and he escaped.

Except for his left arm, which is weak, he is a powerful man. He says that when he remains inactive the arm gives him very little trouble, but when he uses it much it swells and becomes very painful. Pus frequently forms in the scars and one or two were in this condition at that time. It was almost unbelievable that he was not killed by the animal.

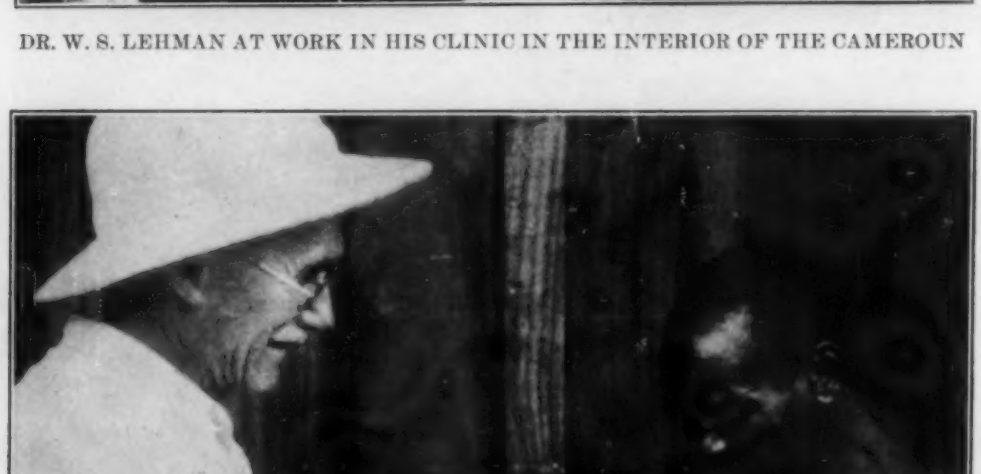
Such experiences are rare, but occasionally gorillas do harm the natives. In

A BOY WITH SLEEPING SICKNESS.
THIS LETHARGIC AND EMACIATED STATE REPRESENTS A LATER STAGE OF THE DISEASE.

the same village was a woman who years before had complained to the men that she was afraid to go into the low second growth to gather plantains and bananas because gorillas were there. The men told her to make a noise and the gorillas would run away. This she said she did, and a big gorilla rushed toward her, and as he went he gave her a back-handed slap that knocked her down and almost tore one breast off.

Near the end of my stay in the Cameroun I had carried my embalmed gorillas down to the coast on a motor truck and

DR. W. S. LEHMAN AT WORK IN HIS CLINIC IN THE INTERIOR OF THE CAMEROUN



A SURE WAY TO SEE THAT THE PATIENT GETS THE PROPER DOSE IS TO PAINT THE AMOUNT ON HIS DARK SKIN WITH CHALK.

was returning when I met three natives carrying a man on a sling made of a pole and some burlap bags. As I came near they asked me if I would take the sick man to the next village on the truck. When I asked what was the matter with him, they told me that he had been bitten on the leg by a gorilla over on a near-by hill. I asked, "Where is the gorilla?" and they replied, "Oh, he ran away." So I took him along to the village. On the way there the men told me that the sick man had been hunting with dogs for wild pigs when one of the dogs had run close to a gorilla. The animal dashed after the dog, who took refuge between his master's feet, and as the man turned to run the gorilla grabbed him by the ankle and sank his large canines into the calf of his leg. When we reached the village I told them to take off the dirty rags bound around the leg, so that I might see the wound. When I looked at it I could clearly see the marks of the gorilla's great canines. I remarked, "This is no fresh wound. When did this happen?" They replied, "About three months ago." With medical care his wounds would probably long since have healed.

One of the medical missionaries told me of a case where a gorilla had been shot and wounded by a native hunter. The animal charged the man and bit him on the arm or leg and then ran off. The doctor was called to attend this man's wounds. In addition to the bites the doctor saw a clean, deep cut through the man's knee. He said, "This wound was made by a knife, not by a gorilla." The wounded man maintained that it was made by the gorilla, but later his companion admitted that when the gorilla grabbed his friend he struck at it with his big machete-like knife. The blow missed the gorilla and cut his friend's knee.

As the natives travel through the forest, if they hear gorillas near by they make a detour to keep out of their way. On the other hand, should a group of natives, talking as they walk along, come near a group of gorillas, the gorillas would quietly move off and, unless followed, would make no demonstration. It is only when they are followed or come upon suddenly, when some of the group are feeding on fruit or up in a tree, that an old male will attack.

For centuries past the gorillas and natives have been competitors. As the native population increased, new villages

AN OLD WOMAN WITH SLEEPING SICKNESS.

would be formed and more clearings made. Then epidemics would occur, killing off great numbers of natives, and their gardens would be neglected to run into second growth. The gorillas, with a constitution so nearly like that of man that they can find more food in human plantations than in the virgin forest, would move into these deserted clearings. There with an abundance of food they throve and congregated, to such an ex-

tent eventually that if only a few natives remained they were actually driven out because of their inability to protect their crops against the gorillas. But with the advent of the white men's government, with the distribution of firearms among the natives, preventive medicine and the treatment for epidemic and infective diseases, man has the upper hand at present in this age-long struggle.

Natives often told me: "If we could only find a group of gorillas up in a tree after fruit, we would be able to kill all or any we wished." On one occasion while I was at Djaposten natives of a village twenty miles away had come across gorillas in this way and killed several as they descended the tree. Several times I was able to follow gorillas closely enough to see the vegetation move as they descended the big forest trees that were bearing fruit. However, it was very difficult to approach gorillas under these circumstances, because they would be scattered about and one or another would invariably detect me or my companion before I had been able to find the particular gorilla I wished to collect.

Another time I approached a group of gorillas that we had been following most of the morning. There were monkeys feeding in the trees overhead and big hornbills that made a great deal of noise. The gorillas were just at the edge of a palm swamp when I came up with them and one half-grown one was up in a tree on our right. Directly ahead of me in the swamp were two baby gorillas, probably not more than fifty pounds in weight each, playing together on the ground as the adults were feeding near by. I waited, sure that within a moment one of the adults must come into view. Suddenly the one on our right became alarmed and started to climb down the tree, then dropped from a height of perhaps twenty feet or more, tearing down

DR. LEHMAN AND HIS MEDICAL BOYS.
THE NATIVES ARE TRAINED AS TECHNICIANS AND NURSES.

MOTHERS BRING THEIR BABIES, IN THIS CASE TWINS, TO THE CLINIC, USUALLY FOR TREATMENT, SOMETIMES JUST TO SHOW THEM OFF.

vines and leaves that encircled the bole of the tree. Malong rushed toward him as he dropped, but he made off through the underbrush without making an outcry. A few minutes later, however, he gave an alarm and the whole group hurried away.

A few days later Malong and I were hunting in this same locality. The ground was slightly undulating and the forest was heavy. We had been tracking a solitary gorilla for some time and we were both very keen to get this animal. On two or three occasions we had heard him beat his chest and we could tell from his movements and the size of his

footprints that he was a large animal. Malong crawled just ahead of me and cut the vines with my knife, so that we might go forward without the slightest sound. We moved as quickly as we dared, for as the sun rose higher the leaves on the forest floor would dry and crackle. On two or three occasions we got a momentary glimpse of the animal and from the springy way he stamped and bounded about he seemed to be full of life and vigor. After about two hours I got a glimpse of him sitting in a tree fifteen or twenty feet above the ground, a small tree not more than ten inches in diameter. When I fired I was perhaps thirty yards away. He fell forward, I saw the outline of his upper part and thought I had shot at the back of his head. Later I was greatly disappointed to find that I had not seen his head but the back of his neck. The bullet passed through the upper part of his chest and right shoulder, which apparently had been raised at the time. This made it very difficult to embalm the animal.

It was just 11:30 when he was shot. Malong and I made a trail by compass back to camp. By hurrying we had reestablished camp near the gorilla by late afternoon, when I began embalming the animal. We camped there that night.

The following morning I sent a man to Djaposten for porters to cut a trail and carry out the gorilla. I worked all day on the animal, while every available man was employed on the trail. Several more men arrived that night from Djaposten.

When the gorilla was fairly well embalmed I sent Malong, Ze and seven other men to finish the work on the trail, while sixteen others made a *tepoy* or litter on which to carry the gorilla. When this was finished they began the journey back along the trail with the animal, while still other natives carried outfit. I went along with the gorilla for some time and then on ahead, cutting a tree here and there.

I arrived at Djaposten at 4:30 in the afternoon and sent Tsama and one or two others back to tell the porters that under no condition were they to stop but to keep moving until they got to Djaposten. Late that night I could hear chanting and realized that they were approaching. Finally at 1:30 in the morning they came in, bearing the gorilla.

Just before they arrived one man came limping along on a stick, holding up one foot and moaning. He dropped down beside me and showed me that he had a big thorn directly in the bottom of his heel. With a pair of pliers I was able to extract the thorn, which stuck nearly three quarters of an inch into the flesh.

I had never known a more surly lot of natives than this group when they set the litter with the gorilla on the ground. All they would say was, "You bin kill we for today." They had been carrying the gorilla, which weighed approximately three hundred and seventy-five pounds, on a litter made of green saplings weighing probably one hundred and fifty pounds more, from about seven o'clock in the morning until one-thirty the following morning, through swamps and over a fresh-cut trail where there were thorns, sharp sticks and driver ants.

A day or two later, in order to insure the perfect preservation of the animal, I had a woman dig a hole eighteen inches deep and six feet long in the floor of a hut. In this hole I put a canvas tarpaulin, which I waterproofed by painting it with paraffin wax. I then put the gorilla in there with embalming fluid.

While waiting in Djaposten I decided that an easier way to get gorillas would be to use native dogs. I thought native dogs were worthless until I tried to buy them. The first of these worthless animals cost me a hundred francs (about four dollars in our money); another, supposed to have been bred from a "white-man dog," a hundred and fifty francs, which exactly equalled my cook's wages

ARBUP, A MAN WITH A SHAVEN CROWN, BECAME NURSE FOR MY BABY GORILLA.

for two months. The natives were very fond of their dogs and in bargaining for them I had to keep going up until I hit a sum which made them throw affection to the winds. It took some time to get these dogs to come anywhere near me. I kept them tied up about camp and fed them meat when that was available and other food that they would eat, such as bananas and papayas, until their fear of

the white man was overcome. However, they were useless as hunting dogs because they were very much afraid of even wild pigs in the forest, and as soon as we got on the trail of a gorilla they all wanted either to walk right under my feet or to run back to camp. By the time I had proved to my satisfaction that these dogs were useless, the natives who had owned them and wanted them back had, of course, spent all the money and had no means of paying for them.

Natives told me that sometimes when a dog came near a gorilla the gorilla would simply stand still until he considered the dog within reach, when he would suddenly grab him and slam him on the ground. This was the end of the dog.

After I had obtained the first gorilla in this region, natives told me of a place about eighteen kilometers along the road where there had been two or three villages, now deserted, so that the whole place was covered with second growth and gorillas found an abundance of food there. I decided to investigate this locality, but on the morning of my departure I was surprised to learn that one or two of my best porters refused to go, saying that people that went there died of sleeping sickness. I had been told that there were no inhabitants and I considered that one was less apt to find infected tsetse flies there than about inhabited villages. When we reached there I found a deserted hut by the roadside, but all about was the densest type of jungle and the remains of a great many native houses that had tumbled down.

I had been there but a short time and was out early morning hunting with two or three natives when I was taken with fever. I could scarcely walk back to camp. I remember sitting in a camp chair beside the fire in a dark palm-thatched hut without windows. Late that afternoon my boy told me that they had heard a gorilla near by and that some of the natives said that this gorilla had crossed the road on many occasions. I took my gun and went out to the road. This was a motor road kept open by the French government so that one truck a week was able to go down to Lomie and keep in communication with the French official there. However, I soon found that I was unable to stand and after waiting a few moments went back into the hut. I spent the following day in bed, was unable to eat and had a fever of 105°.

That night I awoke and found the hut full of natives. Tsama told me that I had been talking, but they could not understand anything I said. This was about eight-thirty in the evening and I learned that an hour before, realizing that I was very sick, they had sent a boy to walk fifty-five miles to Nkol Mvolan to call Dr. Lehman. They said that if the boy was not lazy he should reach Dr. Lehman by ten o'clock the following morning.

Later that same night I could hear people coming along the road wailing, as I had often heard them when one of their own was dead or dying. Natives arrived and, still wailing, came right into the hut and stood around my cot staring at me. Several times I remember telling the boys to send them outside. It seemed that word had been carried along the road in one direction by the messenger to Dr. Lehman, in the other by some one else. The verdict of the natives was, as I heard them say when they left my bed: "This white man will die tonight and if he doesn't die tonight, he will die tomorrow." I knew only that I had a terrific headache, felt very weak and later was unable to sleep.

The following evening I heard the natives shouting outside, then there was the sound of a motorcycle. A few minutes later Dr. Lehman came in. He told me that the boy had arrived at his place at two o'clock that afternoon, having covered fifty-five miles in nineteen hours, without stopping. Dr. Lehman, having

ONE OF THE FIRST PICTURES OF MESHIE, A BABY CHIMPANZEE ONE YEAR OLD.

been told that I was seriously ill, had come immediately. He gave me an injection of strychnine and then hurried on to Djaposten, but returned in about an hour and spent the night in my hut.

There was a severe electric storm during the night and though this made the road bad, he said: "I must try to get you to Abong Mbang. I will go there to see the Commissaire and if their truck is

there, I will come back immediately for you."

He left at daybreak and was back shortly after noon with the truck. The natives had to fold up my camp cot a little in order to get it through the door with me. Then we were out in the blinding midday light and the natives stood about while Dr. Lehman read a prayer. After that I was shoved into the truck.

That three-hour trip to Nkol Mvolan was about the worst ride I ever had. However, with the wonderful care and treatment given me by Dr. Lehman at his home I was soon able to be up and about. Dr. Lehman tried to persuade me to return to the States, but I wanted to go back to Djaposten to try to get two more gorillas and some chimpanzees. I realized that I should be unable to hunt myself, but I intended to let the natives do the hunting and I would prepare the animals when they had secured them.

Dr. Lehman often remarked that my boy Tsama was anything but a cook, but he was the only one of the three boys I had brought from Yaoundé that was still with me. In the many months that I had been living about Djaposten I had lived to a large extent on the native food. Dr. Lehman said, in a later note advising me to return home: "It is not likely you can get better with the cook you have and the food available there."

While I was sick at Dr. Lehman's, Tsama told me one day that Nkoicha (Dr. Lehman's cook, who had been trained for years by Mrs. Lehman) was making cookies. On occasions when Dr. Lehman had come to Djaposten he had brought a tin of these cookies and Tsama knew that I liked them. I told him once that if he were a good cook, he could make cookies too. So now I told him to go and see how Nkoicha made cookies and later he told me he had the receipt written down.

Back at Djaposten a few weeks later, one afternoon as I was starting out to hunt Tsama came to me and said, "Monsieur, I like for make cookies." Not wishing him to waste my supplies, I said, "Bring dem receipt." He brought it and I showed him how to divide it in order to make half the amount called for, for he did not know, for instance, what was a quarter or a third of a cup of ingredients. I returned from the forest just before dark and Tsama said with a smile, "Monsieur, cookies live for table." He followed me into the house, where I saw some cookies on a plate and others in a tin. He was eager to have me try them immediately and said, "Monsieur, chop 'em just now." I picked up a cookie and remarked, "Tsama, plenty fat live for dem cookies." He replied, "Ya, 'e be plenty fat." I then asked, "How 'e be plenty fat? No plenty fat live for dem receipt." He answered, "But for dem paper 'e live two receipt, one for cookies, one for doughnuts. For cook 'em I bin take receipt for doughnuts." In other words, they were boiled in oil.

The examinations that Dr. Lehman put me through showed that I had contracted sleeping sickness, two kinds of malaria, hookworm, ascariasis (infection with the roundworm *Ascaris*) and a number of other intestinal parasites. It is not surprising that an occasional white man, living practically as the natives do, should be affected with some of these things, for at the time of my visit in that district it was said that 65 per cent. of the natives had sleeping sickness, somewhat over 33 per cent. had malaria, and other diseases, such as syphilis, yaws and leprosy, were common. A great many natives were infected with *Filaria*, mostly of the type carried by the "osun" fly. One of my porters who contracted sleeping sickness seemed to suffer in about the same way that I did. Unfortunately he did not seem to respond to the treatment and died after four years.

It might be supposed that it was simply through carelessness that I had acquired

MESHIE PLAYING IN THE WATER WITH MPENIMAW'S CHILDREN AT DJAPOSTEN.

all these infections. It was not, for I was well aware of the dangers of infection and naturally had tried to avoid it. The four white men that originally composed our party had all taken quinine regularly during the entire trip as a prophylaxis against malaria, and none of the others suffered with it. But I had been in the neighborhood of Djaposten for a much longer period of time than I had planned and had run out of quinine for a short time before the extra supply arrived. It was during this time that I had my first attack of malaria. This seemed to weaken me so much that even after I got quinine the ordinary prophylactic dose did not prevent recurrence of the disease. It was necessary for me to take thirty grains a day for two months and then to continue with slightly smaller doses for two months more.

Of course in camp and in traveling we were always very careful to have our cots covered with mosquito netting and to search the inside of the net by means of an electric torch after we had tucked ourselves in. But naturally in hunting in the forest and being about camp in the early morning and evening we might be bitten by *Anopheles* without knowing it. This would be much less likely if one resided in a screened bungalow, which is the usual thing at the present time for people living in the tropics.

The boys are given to understand that all water for drinking purposes must always be boiled in order to avoid possible dysentery or certain types of *Filaria,* typhus or typhoid, etc. Nevertheless, Dr. Engle acquired dysentery while in the Belgian Congo, and though he received medical care there he was in-

MESHIE IN HER AMERICAN HOME.

capacitated for many months after his return home.

One may acquire such things as roundworms (*Ascaris*) if the boys do not use boiled water for washing dishes and also from using dish-cloths which have not been sterilized and which may have touched the ground, where the ova of these animals are to be found. *Ascaris* is a very common infection of children when they are crawling around on the bare ground. Sometimes a child will contain hundreds of these worms at one time. The adult worms are about a quarter of an inch in diameter and six inches long.

Hookworm is usually acquired either by direct contamination of food or water or by going barefooted, but one may also get it by wearing leaky shoes, which was my case. The extremely minute larval hookworm, coming in contact with the soles of the feet, is said to burrow through the skin and work its way into the lymphatics, which it follows to the thoracic duct and there enters the blood stream. In the blood stream it goes to the lungs, works its way through the lung tissue into the bronchi, then goes up the trachea and down the esophagus, passes through the stomach, and finally becomes attached along the walls of the duodenum, where it lives on the blood.

In the Cameroun the guinea worm,

which is a filarian reaching a yard in length, is rare. However, there are smaller filarians which are very common. Perhaps the most common is the eye-worm, *Filaria loa*. The microscopic stage of this animal is carried by a tabanid fly known to the natives as "osun," which is common, especially in dry weather. These filarians grow in the subcutaneous tissues and in the small veins and lymphatic vessels, especially of the extremities. This, I believe, is the organism that frequently causes elephantiasis. On a number of occasions when I assisted Dr. Lehman at operations these worms were found in the tissues. As a rule, however, they cause little inconvenience.

I saw no infections of tapeworm in the Cameroun, but I suppose they occur there, as one of the gorillas we killed in the Kivu was very heavily infected.

Yaws, syphilis and leprosy, though common, are no more likely to be acquired by white travelers in Africa than elsewhere. Yaws is very prevalent among the natives; the missionaries told me that the natives had regarded this disease much as we might regard measles, mumps or whooping cough, and apparently felt that everybody had to have it. But they had different names for the preliminary, secondary and tertiary forms of the disease and did not recognize them as stages of the same disease. Hundreds of lepers were being treated with an extract of chaulmoogra oil, which apparently cures this disease.

While at Dr. Lehman's home I saw a great deal of the wonderful work that he, like other medical missionaries, is doing. Great numbers of natives were examined for sleeping sickness, malaria, yaws and all sorts of other diseases and the infected persons were treated. Children who contracted sleeping sickness sometimes became very fat in the first stages of the disease; then as its effects progressed gradually began to waste away until some looked, as all the affected adults did, like living skeletons.

During the latter part of the time that I was in camp near Djaposten a couple of natives came in to my camp bringing a little chimpanzee, which I bought for three hundred and fifty francs (about fourteen dollars). She was a tiny little thing, not more than a year old and weighing about ten pounds. We called her Mon-A-Waa, Child-of-a Chimpanzee. Shortly after I returned to Djaposten she was playing with children and I heard them calling her Meshie-Mungkut (referring to her swaggering walk), and this name she retained. She became a great pet and very soon learned to sit beside me when I was having my meals in camp and to eat with a spoon and fork and follow me about wherever I went. When I drove a motor truck she sat beside me, but as I had no windshield the wind would blow in her face. This she disliked very much and consequently would keep her face so screwed up that absolutely every particle of skin was occupied by wrinkles.

To summarize briefly Meshie's later history, which has been written in many magazines in the United States and abroad, she returned to America with me and for about four years was the companion of my children in my home. She was so intelligent and learned so many things easily that a wider and wider circle of people became interested in her. I finally took her with me on my lecture tours to show what a young anthropoid was capable of learning in a human environment. Meshie made a great many friends during that time, and when she became too strong to be a safe playmate, we all parted from her with regret. She now has a good home and a happy life more in keeping with her natural state in the Brookfield Zoological Park of Chicago.

After spending about nine months in the forest near Djaposten I left there,

having secured in that region two adult male gorillas, which I embalmed, as well as some chimpanzees and the skeletons of gorillas and chimpanzees which I salvaged from natives. I then returned to Yaoundé and made a trip in the direction of Akonalinga, where I secured another fine adult male gorilla.

Finally, having collected all the material originally planned by the expedition, I sailed for home on January 5, 1931.

In conclusion, I wish to express my deep appreciation to my friends of the American Presbyterian Mission in the Cameroun for their innumerable kindnesses, to the officials of the Cameroun for their courtesies and to the many natives who served our expedition faithfully.

POSTSCRIPT

By William K. Gregory

As both Columbia Unversity and the American Museum of Natural History stood for the protection and conservation of the gorilla, Mr. Raven made no attempt to exceed the modest quota allowed the expedition officially, although in previous years collectors had organized drives and secured great collections of gorilla skins and skeletons. Moreover, Mr. Raven had opportunity to witness the unfortunate effect, so far as the protection of the gorilla was concerned, of the demand for gorilla skulls on the part of scientists, to such a degree that white men as well as natives had in the past often done a profitable business in killing the animals and selling their skulls. The result had been a rapid decrease in the gorilla population, so that Mr. Raven, although by his record known to be a hunter and collector of the first rank, was compelled to hunt week after week in a desperate effort to come up with the nervous survivors of the race in this district.

Nevertheless, Mr. Raven's experience leads him to believe that while the gorilla is being rapidly exterminated in many localities, it may be actually increasing in others, as in the district northwest of Lake Edward, recently visited by Martin and Osa Johnson.

Dr. Engle, whom we left at Stanleyville when we started for West Africa, obtained the remaining records and photographs needed by Professor Morton, made many interesting observations in the hospitals and medical research stations along the Congo River and then returned to New York. He has summarized his impressions of the effect of white civilization upon native life in the *Columbia University Quarterly* for June, 1932.

Upon each of us Africa has set the seal of its magic. And whenever the fancy strikes me I can stand again in the forest on the mountains near Lake Kivu and hear the old gorilla utter his defiant scream.

ARBORETA, OLD AND NEW

By JOHN G. JACK
ASSISTANT PROFESSOR OF DENDROLOGY, HARVARD UNIVERSITY

THE question is often asked, "What is an arboretum, what is its purpose and its limitations?" Briefly it may be described as a collection of living trees and other plants having woody or ligneous stems above ground, that is, including shrubs and woody vines in addition to trees. Such a collection is understood to include an assortment of species brought together and planted for experimental, comparative or ornamental purposes, as distinguished from a plantation of one or few species which we designate as a grove. An orchard is really a form of an arboretum, but is usually understood to comprise trees planted for culinary or other directly economic products. Most arboreta are connected with or form parts of botanic gardens. The trees and shrubs which make up the collections may be scientifically arranged in sequence according to an accepted botanical classification or they may be grouped according to ecological factors or for their uses or with considerations of landscape or, as often prevails, in plantations where families and species are indiscriminately mixed.

While the Latin word *arboretum* is usually applied to the collection of trees and shrubs planted for comparative study or scientific purposes, the Latin word *arbustum* is sometimes used to designate the same thing and has essentially the same meaning. Thus we have the "Arbustum Americanum" of Humphry Marshall, published in 1785, one of the earliest botanical publications in America, by a native-born American, on native trees and shrubs known to that time. In a close analysis or differentiation, the word *arboretum* would be strictly applied to trees, while the term *fruticetum* would comprise shrubs and other woody plants which could not be classed as arborescent. But *arboretum*, as now most commonly used, includes shrubs and woody vines or climbers. However, a plant which grows as a tree in some situations may be reduced to a shrubby form in others, as in valleys or high, exposed parts of mountains, or a species of plant considered as a shrub may occasionally be found to become arborescent. Therefore the line separating a tree from a shrub may be stated as artificial, arbitrary and often difficult to establish. The definition of a tree differs somewhat with different authorities. The late George B. Sudworth, dendrologist of the U. S. Forest Service at Washington, stated "the definition of a tree is based on habit rather than size, and includes such woody plants as produce in nature a single trunk branching more or less above the ground." Plants which normally produce several stems from the same root are by this rule excluded, although their plural stems may sometimes attain large size, as in some species of alders, willows, etc. A scientific definition is that given by the late Professor B. E. Fernow, one-time chief forester of the United States and afterwards head of the forestry departments of Cornell and Toronto Universities. His definition is: "Trees are woody plants, the seed of which has the inherent capacity of producing naturally, within their native limits, one main erect axis bearing a definite crown, continuing to grow for a number of years more vigorously than the lateral axes, and the lower branches dying off in time."[1]

As it is not always easy to define

[1] "Garden and Forest," Vol. 1, p. 410, 1888.

whether a species is entitled to be ranked as a tree or a shrub, so it sometimes is difficult to decide whether a plant usually classed as a herbaceous perennial should not be placed in the rank of shrubs or subshrubs, fruticose or suffruticose. For there are many so-called herbs which develop more or less ligneous crowns or short, woody stems above ground. Tropical or subtropical plants, like lantanas, heliotrope, etc., cultivated in northern gardens as annuals, may be substantial shrubs in their home environments. A native species which may appear as distinctly herbaceous in its northern range may develop a decidedly woody character in its southern limits or under peculiar ecological conditions. Thus there is really no sharp dividing line between trees, shrubs and herbaceous perennials. They are more or less interrelated and naturally should go as a unit for a botanic garden of hardy plants. This was the intent of the trustees who conveyed the Arnold fund, founding the Arnold Arboretum, to Harvard College, a trust which was never fully carried out, as the "herbaceous plants" stipulated were never included by the management.

With the early collections of trees there were usually associated shrubs, vines and herbs, the latter often being the dominant feature of what came to be known as "physic gardens," where special attention was given to medicinal plants and to those furnishing sustenance among such groups as monks or priests, who avoided the use of animal or flesh foods. In past ages, hundreds or thousands of years before the Christian era, such peoples as the Chinese and the Egyptians had their gardens which contained trees, shrubs and herbs, native or brought from distant lands, the best collections being about temples and cemeteries.

The formation of arboreta or collections of trees long antedates the records which have been handed down to us in the earliest writings which have been preserved. Very naturally the early selections and collections of trees, together with herbs, had to do with their direct utility, in a domestic sense, to human needs and desires, particularly those which afforded foods, spices and drugs. Southern Asia and Europe, now regarded as the natural garden in which originated the most useful species of our apples, pears, quinces, plums, almonds, cherries, figs, olives, oranges, pomegranates, furnished the tribes, usually regarded as semi-civilized, with a considerable variety in their diet. Thus collections of trees or orchards were first formed long before books were printed about them. Primitive names for operation or management, such as planting, pruning, grafting, etc., were in use long before they were written. Of course there are references to trees and other botanical objects in the early scriptural stories. From these it would appear that Solomon had collected a great variety of trees and other plants, forming an orchard or arboretum of fruit trees bearing edible fruits, and trees producing spices, as well as so-called "barren trees," as the Cedar of Lebanon (*Cedrus libanotica*). In early records there is frequent mention of palms, cypress, fig, olive, cinnamon, camphor and others, some of questionable identity. However, these are not recorded as forming definite groups or collections, arboreta or orchards.

The best available source of positive information concerning the trees known to the peoples or nations of antiquity is to be found in the works of Theophrastus, sometimes called the "Father of Botany," which give us the best history of trees known to the Greeks down to the third or fourth century before the Christian era. In his famous and exhaustive "History of Plants" Theophrastus described hundreds of kinds of plants, a large proportion of them with sufficient accuracy to enable modern botanists to identify and classify them in modern botanical terms.

It appears that, upon his death, Aristotle left his garden, in the Lyceum in Athens, to his pupil Theophrastus, and no doubt it was in this garden and arboretum that Theophrastus made many of the interesting observations recorded in his "History of Plants," of which there are translations in a number of languages. From the studies of botanical investigators into the identity of species of trees and shrubs known to Theophrastus it would appear[2] that he was acquainted with not less than 170 species, belonging to 53 natural groups, in addition to others which remain in doubt because of inadequate descriptions. Naturally a large proportion of these trees and shrubs were natives of Greece. The list includes a considerable number of great economic or historical interest, some of them brought from other regions. It is not claimed that all the species known to Theophrastus existed in the garden which he inherited from Aristotle, but no doubt a considerable proportion were to be found there. Aristotle is understood to have written two books on plants before the "History of Plants," but these did not survive the passing centuries and are forever lost. The "History of Plants," by Theophrastus, brings us some idea of what must have been the interest in trees before his time, never recorded in writing but passing down from generation to generation and exhibiting a surprising knowledge of plant variations in wild species or their cultivated forms. In various species he records that some superior forms have been named and that when these are grown from seed there is likely to be degeneracy. Besides seeds he speaks of propagation by cuttings, root cuttings and grafting, in terms which compare well with many of the essays by writers of the present day.

Only as a story do we know of the garden of Alcinous, which existed about 600 years before the time of Theophrastus, or a thousand years before the beginning of the Christian era. The record of this garden is essentially legendary. Homer has given us, in the "Odyssey," a picture of it. It probably existed and contained an assortment of trees, mainly those having an economic or esthetic value, and was considered wonderful in its time. Dioscorides, who lived and wrote his famous "Materia Medica" in the first century of the Christian era, gives us valuable information on the botany of his time and earlier, but of course this has no relation to any particular form of botanic garden or arboretum.

As already stated, these early collections were essentially of utilitarian interest closely related to general horticulture rather than of a purely arboricultural character, but they serve to show a trend to an interest in trees and shrubs which has finally developed into collections which are purely arboricultural or sylvicultural in purpose.

The Romans seem to have largely acquired their knowledge of trees from the Greeks, although numerous exotic species were introduced, so that an enumeration of the plants known to and introduced by them would show an acquaintance with most of the important species now recognized as native to Europe. Pliny in his famous "Natural History" gives us by far the best account of trees as known to the Romans in the first century of the Christian era. While he does not particularly enumerate trees as aggregated into collections or arboreta, he does give us an account of the most interesting kinds known to his countrymen. That trees, outside of orchard collections, were planted in groups or groves and highly considered, may be best shown by the following quotation from Holland's Translation of Pliny's "Natural History" (p. 357):

"In old times trees were the very temples of the gods; and, according to the ancient manner, the plain and simple peasants of the country,

[2] Loudon, "Arboretum et Fruticetum Britannicum," Vol. 1, p. 17.

savouring still of antiquity, do at this day consecrate to one god or other the goodliest and fairest trees that they can meet withall; and verily, we ourselves adore, not with more reverence and devotion, the stately images of gods within our temples (made though they be of glittering gold and beautiful ivory), than the very groves and tufts of trees, wherein we worship the same gods in religious silence. First, the ancient ceremony of dedicating this and that kind of tree to several gods, as proper and peculiar to them, was always observed, and continues to this day. For the great mighty oak, named esculus, is consecrated to Jupiter, the laurel to Apollo, the olive to Minerva, the myrtle to Venus, and the poplar to Hercules."

Thus we have the ancients of two or three thousand years ago dedicating trees to gods or individuals, a custom which has survived through the ages and which we follow in dedicating particular trees to persons or their memories on our arbor days or other special occasions. There is no doubt that in very early times cemeteries, temples and monasteries were the centers in or about which trees of various sorts were introduced, thus forming groves or primitive arboreta, though without such a considered purpose. Traveling priests and explorers brought home new trees and other plants from the lands they visited. Chinese records tell us that the Han Emperor Wu Ti, who lived 140–86 B.C., through one of his agents or missions sent to southern lands, was responsible for the introduction of walnut, pomegranate, grapes and other plants.[3] Some of these are now so naturalized or incorporated with the original Chinese flora that their true native home is a disputed matter. Some students of history now credit the Chinese with being the definite pioneers in the formation of botanic gardens made up of both herbs and trees, the latter persisting longer as remnants of what might have been called small arboreta.

We have unsatisfactory records of a Royal Garden and a garden about the temple of Karnak, in Thebes, Egypt, in the time of Thothmes III, about 1500 B.C., where palms and other plants were grown, but the variety was probably very limited and the place designed for pleasure rather than for more practical purposes. Very little is known of the gardens and botanical collections of the ancients for ten or twelve centuries after the dawn of the Christian era. From that time onward we know more definitely about the botanists and botanical works and the gradual development of collections for practical use or scientific study. Herbs dominated in the gardens of "simples" or "physic gardens," as they were commonly called, which, in the fourteenth and fifteenth centuries were often attached to monasteries or to schools of learning where medicine was studied, particularly such institutions in southern Europe. One of the oldest and most famous of the collections of "simples" was the botanic garden at Padua, Italy, which was founded in 1545 and still exists on the same ground. Like most gardens of this era, the land area was small and precluded the admission of many trees.

Other famous gardens in Italy which were founded about the same time, or soon after that at Padua, were gardens at Pisa and at Bologna. The garden at Zürich was founded in 1560; in France the most famous were the gardens at Montpellier, in 1598, and at Paris in 1597, which is known to us now as the *Jardin des Plantes*. In this garden were grown many species of interesting introduced trees, though the collections of other gardens mentioned were mainly herbaceous. Important botanic gardens were established in Germany at Leipzig in 1579, Strasburg in 1620, Berlin in 1679. Sweden had an established garden at Upsala in 1657, and in Holland the garden at Amsterdam dates its foundation from 1682. While none of these contained definite arboreta, classed as such, they did contain interesting exotic trees of economic value and gave impetus

[3] E. Bretschneider, "Botanicon Sinicum," Part 1, pp. 24–25, 1881.

to the formation of special and separate collections of woody plants. Among similar early gardens in Great Britain were the garden at Oxford, established in 1621, Chelsea in 1673 and Edinburgh in 1680. In Edinburgh there were rival gardens for many years, the remaining present one being under the University and Medical School. Various public and private arboreta were established in the following years and through the eighteenth century, both in continental Europe and in Great Britain. Some of the public or semi-public establishments have ceased to exist and private collections have mostly been lost through lack of interest by generations which succeeded the founders.

Many small private collections of trees and shrubs were established in Great Britain during the eighteenth and nineteenth centuries and some of these are well worth while visiting to-day. In the south of England and Ireland there are growing in the open air hundreds of species of trees and shrubs which it is impossible to grow in northeastern North America.

The Royal Botanic Garden at Kew, or Kew Gardens, as we familiarly call them, form the center from which has emanated much of the inspiration which pervades plant enthusiasts and arboriculturists in all civilized parts of our globe. The beginning of Kew Gardens may be dated as from 1759 or 1760. About that time Princess Augusta, Princess Dowager of Wales, being much interested in botany, had set apart about nine acres of the Royal Garden attached to Kew House for the purpose of forming a physic garden, and an arboretum to contain all the then known hardy trees and shrubs. This appears to be about the first definitely designated and important "Arboretum." In 1772, George III inherited the Kew House property and united the gardens of the palace with those lying adjacent and so made up the extensive territory now known as the Royal Botanic Gardens at Kew.

Sir Joseph Banks was chosen to administer the garden, which he did for 48 years, during which time it prospered greatly and gained vast influence in the botanical and horticultural world through exploration and experimentation. Following the death of Sir Joseph Banks in 1820, there followed a quarter of a century when Kew fell in efficiency, but after the appointment of Sir William Hooker to the directorship, in 1841, the institution soon resumed a commanding position in the botanical world, which it still holds. No botanical institution has been so indefatigable in exploring all parts of the globe for plants of economic or scientific interest and in distributing its acquisitions among botanic garden stations in the widely scattered British colonies and to botanical institutions wherever founded. The great herbarium is the most important in existence and with this are various museums for the illustration of phases of plant life. But the Botanic Gardens and Arboretum, covering 288 acres, are the special objects of interest to all students of living plants. Here, in a latitude which corresponds to that of southern Labrador or the northern tip of Newfoundland, may be found the largest collections to be found within temperate or subtropic zones. That such a collection is possible in the latitude of London is due to the modifying influence of the Gulf Stream which originates in the tropic coasts of America and the Mexican Gulf. Here about 20,000 species and varieties of trees, shrubs and herbaceous plants may be found, labeled and with scientific arrangement whenever practicable. Notwithstanding its large area it is interesting to note that, excepting wheeled chairs propelled by man power, no vehicles are allowed within the gates of Kew, a rule which adds much to an atmosphere of restfulness and the peace of those who resort to the place for observation and study.

The proximity to London, with its smoke and gases, which are not conducive to the best growth in plants, has recently caused the authorities to plan and plant a new arboretum, for conifers at least, much farther from the city and it is conceivable that the time may come that the best part of Kew will be found in new quarters.

Among the tropical or subtropical arboreta established or aided by the British Government, through Kew, may be mentioned the gardens at Jamaica, at Trinidad, in Hongkong, in New Zealand, Australia, India, Ceylon and South Africa. In all these the tree collections are of importance and enable the student to obtain some acquaintance with trees and shrubs of the tropics and subtropics. The garden at Peradeniya, in Ceylon, is especially noteworthy.

Throughout Great Britain there are many small private collections of trees or arboreta, the owners of which got their inspiration from Kew, although much was accomplished through private initiative much earlier than the foundation of the now most famous institution. Space does not allow of mention of any of these.

In Germany the Botanic Garden in Berlin was founded as early as 1679, in the heart of the city, but with an area so small as to preclude any considerable collection of trees. But about 40 years ago the formation of a new Garden at Dahlem, to replace the old Garden in Berlin, was undertaken and was practically completed in 1909. Without doubt this is the most important, next to Kew Gardens, of botanical institutions in temperate zones. The area is only about half that of Kew, but every detail has been elaborately worked out for the plantations, for research and for study. Landscape effects have been strictly subordinated for those of a practical nature, unlike Kew, where vistas and pleasure have been considered as well as development along scientific lines. The Arboretum at Dahlem comprises an area of about 50 acres, the trees and shrubs being planted singly to give each species a full chance to develop its characteristics or peculiarities. The number of hardy species which it is possible to grow at Dahlem is decidedly less than is possible near London, due to the much colder winters in the region of Berlin. Some of the group collections are already the most complete in existence and the institution is a Mecca for arboriculturists, horticulturists and working botanists. Almost every forest school in Germany has its little arboretum, private collections are numerous, and even the most progressive commercial nurseries have instructive groups of trees and shrubs.

The arboretum at Les Barres (Loiret) France, 75 or 80 miles south of Paris, begun in 1825 by the famous horticultural firm of Vilmorin, was bought by the French government in 1866 and is now known as the Arboretum National de Barres. It stands as the best collection of trees in France. In the vicinity is the Fruticetum Vilmorinianum, forming the finest collection of shrubs in the nation. The Les Barres establishment is now used by the state as a school of silviculture.

It is not here possible to more than mention the garden at Leningrad (St. Petersburg), founded in 1713, where Maximowicz, Regel and others did so much for the study and introduction of really hardy trees and shrubs, and of other botanic gardens widely distributed in distant parts of the Soviet Republics where small collections of trees may be found.

While most of the arboreta of the past were naturally associated with or adjuncts to botanical gardens, there were some cases where trees were given first attention. As already intimated, some of the collections have fallen into disorder because of lack of endowment or the fact that later owners did not have the same interests as the founders, or sometimes conditions of population or of climate or environment may so change as

to make abandonment wise or necessary. Such untimely ends are always likely to occur, whether the enterprise is under private or public ownership.

It may interest readers to know that in China at the present time several arboreta of considerable area are in process of development. Chinese students who have studied in the United States and in Europe are enthusiastic promoters of and workers for the enterprises which often receive generous, though inadequate, help from public funds.

While the Dutch in Holland have done much in tree study, it is the Botanic Garden at Buitenzorg, Java, founded in 1817, which is world famous and without any doubt forms the most extensive and complete botanical establishment in the tropics. Covering an area of much more than a thousand acres, there has been assembled a bewildering collection of plants unequalled by any other institution of its kind. Here may be found thousands of species of trees and shrubs from all parts of the tropics, so that nowhere else may the student of botany get such a comprehensive view of the plants of hot climates. Through research the botanical achievements have been great, and the encouragement given to the cultivation of cinchona (quinine), cocoa, coffee, rubber, sugar, spices and other economic products has been of very great value not only in the Dutch East Indies but throughout the tropics where such crops are grown.

Excepting those in the West Indies, which have been mentioned in connection with Kew and the British Government, no reference has been made to tropical gardens or arboreta in the New World. In the garden at Rio de Janeiro, in Brazil, founded in 1808, there is a good opportunity to study palms and other trees in a fine state of development, and the gardens of Santiago, in Chile, and at Buenos Aires, Argentina, have long been well known.

In the Panama Canal Zone an attempt is being made to introduce a large assortment of useful and ornamental trees, and the result should be an interesting arboretum.

While we know little of the ancient history of the peoples of America, it has been authoritatively stated that in Mexico, at the time of the Spanish Conquest, the Aztecs had gardens well worthy of the name. These gardens of the Aztecs were clearly of native origin and in no way connected with similar developments in the Old World. In the "*Nova plantarum animalium et mineralium Mexicanorum historia*" of F. Hernandez, published in 1651, the oldest published natural history of the New World, we have illustrations and Aztec names of trees and shrubs and other plants, many of which probably became known, or better known, to Hernandez through these gardens. Montezuma was known as a patron of gardens. Among other references to Mexican gardens of that era the following description is interesting—"Sandoval took up his quarters in the dwelling of the lord of the place (Chalco), surrounded by gardens, which rivalled those of Iztapalapan in magnificence, and surpassed them in extent. They are said to have been two leagues (about five miles) in circumference, having pleasure houses, and numerous tanks stocked with various kinds of fish; and they were embellished with trees, shrubs and plants, native and exotic, some selected for their beauty and fragrance, others for their medicinal properties. They were scientifically arranged; and the whole establishment displayed a degree of horticultural taste and knowledge, of which it would not have been easy to find a counterpart, at that day, in the more civilized communities of Europe. Such is the testimony not only of the rude Conquerors, but of men of science who visited these beautiful repositories in the day of their glory."[4] This

[4] Prescott's "Conquest of Mexico," Vol. 2.

was in 1521, while the earliest botanic garden in Europe, at Padua, was not established until 1545.

In North America there are now listed between forty and fifty collections under the name "arboretum" and at least a hundred other public and private or semi-private collections which, passing under the classification of "botanic garden," include a fair representation of trees. A list of such institutions was given in the *Arnold Arboretum Bulletin of Popular Information* for September, 1931. In that list Pennsylvania is credited with a larger number than any other state, 21 being listed. What appear to be the oldest attempts to form tree collections in North America, after settlement by Europeans, originated in that state. They were small in area but were valuable and instructive for their time. In 1728 John Bartram, a Quaker, known as a farmer, traveler and botanist, secured a piece of land on the banks of the Schuylkill River about three miles from Philadelphia and there established what became famous as Bartram's Garden. There he brought together a number of American trees collected during his travels and also, through correspondents, introduced a number of species of trees from the Old World. He was instrumental in first introducing numerous American trees into England. After his death in 1777 the garden was allowed, by various owners, to gradually decline until 1891, when it was bought by the city of Philadelphia and included in the park system. Few of the trees planted by Bartram now exist.

Humphry Marshall, already referred to as the author of the "Arbustum Americanum," a relative of John Bartram's, about 1773 planted a collection of trees near West Chester, Pennsylvania, only a few of which are now living. Other interesting collections have been planted in the region of eastern Pennsylvania either privately or in connection with tree nurseries of a commercial nature. Perhaps the most promising is the Morris Arboretum, originally privately established and now under the management of the botanical department of the University of Pennsylvania.

About 95 years ago H. W. Sargent, upon an estate known as Wodenethe, near Fishkill-on-the-Hudson, New York, planted a large variety of native and foreign trees, with conifers prevailing, which became a widely known private arboretum and without doubt did much to promote the public interest in trees and in landscape art.

It is impossible to enumerate in this article the many smaller arboreta started within the past half century and which have been of much help to students of trees. Some of these collections still exist and are growing, others have performed their educational mission and have fallen into decay.

Inhabitants of the far north find an instructive arboretum at the Central Experimental Farm at Ottawa, Canada, which has acted as the parent of subsidiary small experimental collections at numerous stations from Nova Scotia to British Columbia. This central Canadian station may be classed as a National Arboretum. Such an institution has been advocated for many years for Washington, in the District of Columbia, but, although a large tract of land has been acquired, money for construction work has not been appropriated. The site is good and such an establishment in the national capital should become an important educational feature. Like the British Kew Gardens such an institution, with the cooperation of the Department of Agriculture and the National Herbarium, and other advantages, might well become a Mecca-like center to which government experiment stations, colleges and others forming arboreta might naturally turn for help.

Existing arboreta scattered over the country vary in scope from that which specializes only in one family or genus

and their variations, as the so-called "Hemlock Arboretum," to those of such a broad scope as to include all kinds of ligneous plants which may be grown in the particular region and climate in which the establishment is located. Many of our colleges and agricultural experiment stations have now established arboreta as a part of their educational equipment, and parks and the U. S. Forest Service have developed and are developing collections of very decided use in furnishing instruction to the public or as testing grounds of the comparative adaptation and values of trees in forestry or park plantations. A good example of what parks may do may be cited in the case of the Rochester (N. Y.) City Parks, which contain one of the finest named collections of trees and shrubs to be found in our cold temperature zones. Golden Gate Park in San Francisco boasts a very fine and extensive collection of trees and shrubs adapted to the Pacific coast in California.

Among arboreta connected with forestry work or silviculture, we can here only refer to the Wind River Arboretum, Columbia National Forest, near Carson, in Skamania County, Washington, about eight miles north of the Columbia River and located at about 1,200 feet above sea-level. Here possibly useful species of trees, chiefly conifers, from all temperate parts of the globe are being tested especially for silvicultural or reforestation purposes. The number of species grown is limited chiefly to those of known value or probability of adaptation, so that the student of dendrology and forestry may see the actual behavior of species under the prevailing conditions of the region in which they are grown. Although only started in 1912 upon a few acres, the experiment has proved of real interest and will be enlarged as more area is required. It is here referred to as an illustration of what is now being attempted throughout the country.

In recent years in the eastern United States there have been several large undertakings to build up extensive collections of trees and shrubs. Perhaps the most important and most promising is the Morton Arboretum at Lisle, Illinois, about twenty-five miles from Chicago. This was founded by the late Joy Morton in memory of his father, J. Sterling Morton, one time U. S. Secretary of Agriculture. It was begun in 1921, and every effort is being made to create one of the most complete institutions of its kind in the country.

A still more ambitious enterprise is that which is being planned for the vicinity of Cleveland, Ohio, and is tentatively known as the Holden Arboretum. These last two arboreta are in almost exactly the same latitude and both must come under the influence of the Great Lakes, so that experiments and tests carried on by two such museums of living plants should prove interesting and provide valuable practical and scientific data.

The arboreta which form part of the collections of the New York Botanical Garden and of the Brooklyn Botanic Garden, which has the advantage of proximity to Prospect Park, have certainly been important as educational features of these establishments, although their existence goes back only two or three score years.

Many of the foregoing institutions, besides others not here mentioned, unquestionably derived inspiration and much help from the Arnold Arboretum, of Harvard University, in Boston, which may well be considered as having inspired much of the interest in dendrology and arboriculture in North America during the past fifty or sixty years.

As much has been written about this institution and its work it is not necessary to recapitulate its past history here in detail.[5] The property of Harvard

[5] See "The First Fifty Years of the Arnold Arboretum," by Professor C. S. Sargent, in *Journal of the Arnold Arboretum*, Volume 3, January, 1922.

University, an agreement was made with the City of Boston to open it to the public provided that the city build and maintain roads and give police protection, leaving to the college full control of all plantations and experimental work over the more than 250 acres of ground. Seed collecting and plantings in nurseries were begun in 1872, but various delays did not allow of any of the permanent, systematic plantings until the spring of 1886. The Arboretum was fortunate in enjoying exceptional opportunities for the collection of seeds, both North American and from the Old World, and it soon became the medium of extensive exchanges of plant material with institutions and interested individuals at home and abroad. It has been instrumental in introducing into cultivation many hundreds of species of trees and shrubs hitherto unknown in American gardens and its influence in that way certainly was important and far-reaching in enriching plantings in parks and gardens.

Besides such activities the Arnold Arboretum through its educational propaganda by members of the staff and working force has, in the past, exerted a powerful influence in arousing and holding a public interest in arboriculture, horticulture, landscape and park development, and in forestry. For ten years, between 1888 and 1897, the weekly *Garden and Forest*, edited by Professor C. S. Sargent, was probably the most influential medium of the time in arousing an interest in plant life as related to our gardens and forests. But many other scientific publications have emanated from the institution and it has been a study and research station for a large number of American and foreign students in dendrology and forestry.

With the establishment of so many new arboreta and botanical gardens throughout the country, the burden once carried by the Arnold Arboretum has become distributed and it may be that it accomplished a greater public service in the past half century than it is likely to do in future, although it now enjoys a vastly increased income as compared with the meager $3,000 a year from the Arnold legacy when work was begun in 1872. A dream of those who have worked for the institution is a chain of stations in various parts of the country with differing climatic and ecological conditions, so that a better knowledge may be gained of trees and shrubs adapted to the various regions. Already such a station has been well established at Soledad, near Cienfuegos, Cuba, where the Atkins Institute of the Arnold Arboretum is intended to have a representation of useful and otherwise interesting trees and shrubs adapted to the tropics or subtropics of Cuba. It is hoped to specialize in the bringing together of as many as possible of the West Indian or Central American trees, many species of which are rare or fast disappearing. Cuba is particularly rich in species of palms, some of which are widely scattered and little known. This group is a difficult one to study and this may be best done by bringing living specimens together for comparison. Not all kinds of palms will thrive in the climate of Cuba, but already more than 225 species and varieties of palms have been brought into cultivation in the Soledad garden. This station is an illustration of what may yet be established in other parts of continental America in connection with the Arnold Arboretum with its fine library and extensive herbarium in which special students may carry on research supplementary to their studies in living collections.

Under other private, college or government auspices such work is already being done in boreal and in warm temperate localities, on the Atlantic and Pacific slopes, on our plains and under such xerophytic conditions as prevail in Arizona.

THE PROBLEM OF THE ORIGINS OF ALCHEMY

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A NUMBER of recent publications on the origins of alchemy, in particular those of Hopkins,[1] Barnes[2] and Partington,[3] make it apparent that a reconsideration of the whole matter is desirable and that a careful definition of the problem is necessary.

The name of alchemist to most people probably suggests a medieval figure of a man surrounded in his laboratory by the apparatus of chemistry, furnaces, retorts, crucibles, bottles, specimens of animal, vegetable and mineral oddities, an aged man perhaps, blackened by the soot of his labors and still fired with the enthusiasm of his fantastic quest for an elixir of long life or of immortality or for a philosopher's stone by which base metals might be converted into gold and silver. The picture is plainly the picture of a chemist who is devoting his chemistry to very special purposes. A man might conceivably be a chemist, but, if he were not applying his art to the search for the elixir or for transmutation, he would be no alchemist. Another desiring the same results, but without knowledge or practice in chemistry, might perhaps seek to attain them by fasting or by prayer, by systematic deep breathing or by magic ceremonials. He also would be no alchemist. The desiring of the objectives is not enough, nor is the effort to procure them unless it be by chemical means. We therefore conceive alchemy to be the search or the effort, whether successful or not, by chemical means to prepare a medicine of longevity or immortality, or by chemical means to prepare authentic noble metal from base metal or both—the pursuit of either or both of these objectives by chemical means. The beginnings of that search are the beginnings of alchemy.

This conception of alchemy is in agreement with ancient usage. The Alexandrians and Byzantines had χημια, but *al-kimiya* first appeared in Europe among the Arabs about the eighth century. The medieval Latins made clear distinction between *chemia* (or *chimia*) and *alchemia* (or *alchimia*), the latter term at first meaning chemistry of Arabic origin but soon taking on precisely the meaning which we have assigned to it in the foregoing, being reserved for the special quests by which, as it happens, Arabic alchemy was characterized and distinguished from the chemistry of the Alexandrians and Byzantines. Writers of the time of Paracelsus discussed the solid contributions to chemistry which were made by the alchemists. The distinction appears clearly in the writings of Boyle and of Boerhaave, but there were in their time, as there have been since, those who failed to distinguish sharply between alchemy and the ideas and practices which were often but not always necessarily associated with it.

While all writers on the history of chemistry seem to be in agreement with our conception of alchemy, and many have indeed specifically defined it as we have, some of them have frequently proceeded in their writings to use the name in other senses and have thereby increased the difficulties of discovering the origins of the art. Berthelot has called alchemy a pseudo-science, and has stated that its relation to the science of chemistry, which he says grew out of it, is the same as that of astrology to astronomy.

[1] Arthur John Hopkins, "Alchemy, Child of Greek Philosophy," Columbia University Press, 1934.

[2] William H. Barnes, *Nature*, 135: 824, 1935.

[3] J. R. Partington, *Nature*, 136: 287–288, 1935.

Alchemy has been called primitive chemistry, and any chemistry which is ancient enough or sufficiently crude has been called alchemy. Documents of practical chemistry, like the Leiden and Stockholm papyri, and documents of cosmology, like the Emerald Table of Hermes Trismegistos, which contains no chemistry whatever, have been described as documents of alchemy. The "Introduction," which constitutes the first volume of Berthelot's great "Collection des Anciens Alchimistes Grecs,"[4] is identical with the material which constitutes the large part of his "Introduction à l'Etude de la Chimie des Anciens et du Moyen Age."[5] Berthelot used the two names indifferently, and reached conclusions which do not apply strictly either to chemistry or to alchemy.

The history of man divides itself naturally into epochs which correspond to man's increasing ability to apply chemistry to practical purposes. Stone Age man made use of the materials which nature provided and of objects which he was able to fashion from them by physical means. His materials included stone, wood, clay, etc., meteoric iron and native gold, silver and copper. After he had mastered fire, he began to carry out chemical processes in the smelting of ores. The sequence of the chemical ages commenced—the Bronze Age, the Iron Age, the Steel Age and the present Nitrogen Age. The old mythologies tell of metallurgists—Tubal Cain, Hephaistos-Vulcan and the dwarfs who lived under the earth and made the hammer for Thor. A discussion of the beginnings of chemistry is a discussion of the beginnings of civilization wherever and whenever they occurred.

Chemistry accomplished marvelous things. New and altogether surprising phenomena were discovered. It seemed no extravagant hope that chemical processes might lead to the elixir and to transmutation. Alchemy arose at a time when much chemistry was already known. It was not pre-chemistry. It arose in consequence of a pre-existing knowledge of chemistry.

The same conclusion follows from our definition of alchemy as the search for the elixir and for transmutation by chemical means. *Without* the means, how could one conduct the search *with* them?

If the ancient Egyptians considered gold to be an elixir of life, as supposed by Elliot Smith and by Moret,[6] or if they actually used it for that purpose, we are not therefore justified in concluding that they were engaged in the practice of alchemy. To fulfil our definition they must have been trying to make real gold artificially by chemical means, as the Chinese were trying probably as early as the third century B.C., in order that they might use it as a medicine of longevity or of immortality. The Latin workers who later attempted by chemical means to make gold potable, and hence of readier application as an elixir, were alchemists pursuing one of the two prime objectives of their art. They would equally have been alchemists if they had been trying to prepare an elixir by the chemical treatment of limestone or of iron or of barley malt or of any substance whatever.

Primitive man, thinking about the world, early developed theories, at once scientific and religious, cosmological and epistemological, physical and metaphysical, which supplied him with a general explanation of the order of things, a background upon which special theories for special purposes were later superstructed. The oldest such doctrine,

[4] Paris, Steinheil, 1888.

[5] Paris, Steinheil, 1889. 268 pages out of 301 pages of text.

[6] Elliot Smith, "The Ancient Egyptians," London, 1923, pp. 205, 206; Moret, "Le Rituel du Culte Divine," Paris, 1902, cited by Wiedemann, "Das alte Ägypten," Heidelberg, 1920, p. 343; both cited by Partington, "Origins and Development of Applied Chemistry," London, 1935, p. 23.

almost universally prevalent, seems to have been that of the "two contraries," of the father god or positive principle, hot, active, fiery and light, and the mother goddess or negative principle, cold, passive and heavy, by the interaction or combination of which all things in the world were produced and ordered.[7] In due course the general doctrine was applied to the explanation of chemical phenomena—by Zosimos and others. Chemical theories arose. The beginnings of these chemical theories are something that may be discovered and discussed, but they are not the beginnings of alchemy.

The primitive doctrine of the "two contraries" prevailed in Egypt and in Mesopotamia at a very early time. When chemical and alchemical matters aroused interest and became subjects of thought and discussion, they were of course discussed in the language of the prevailing idea-system. An account of the application of the fundamental doctrine of the two opposites[8] to the description of chemical phenomena constitutes a veritable cross-section of the history of chemistry, an account of the sulfur and mercury of Zosimos and Jabir, of the phlogiston of Stahl and Scheele and Priestley, down to the beginning of the nineteenth century. The Leiden and Stockholm papyri, recipe books of practical chemistry of the third century, make no reference to the doctrine. Other treatises of about the same time are pervaded by it, and from that time onward the association between chemistry and ideas based upon the doctrine of the "two contraries" is well-nigh invariable —an invariable but a one-way association, for the ideas in question are always found where chemical matters are being discussed, but chemistry is not invariably present, as scholars have failed sufficiently to note, in all discussions which are based on the ancient doctrine. Documents which contain no chemistry—the Emerald Table of Hermes Trismegistos is a notable example—have mistakenly been regarded as documents of chemistry and even of alchemy, because they are clearly pervaded by the doctrine upon which so many chemical discussions are based.

The doctrine of the "two contraries" appears in discussions of a non-chemical character, it appears in third century Alexandrian chemical texts and in Chinese alchemical treatises of the second century and later. The Alexandrians and the Chinese alike had the same general dualistic background of nature theory, idea-system or world concept. Indeed, the Chinese *Yin-Yang* was probably an importation from Egypt or Mesopotamia, although the matter is not important at the present point in our argument. The Alexandrians, interested in the chemical processes of smelting the metals, of alloying them and of altering their colors in various ways, described their experiments and speculations, naturally enough, by means of a vocabulary which arose out of the dualistic theory. The Chinese alchemists, interested, as we shall see, in the chemical preparation of an elixir and in actual transmutation, likewise spoke from the point of view which prevailed among them. It is natural that the language of the Alexandrian chemists should resemble that of the Chinese alchemists, all the more so as it was the practice of the time to name the reagents obliquely and to maintain secrecy by describing the processes in parables or in fantastic language. We have elsewhere pointed out[9] the simi-

[7] For a fuller discussion of the distinction between the really chemical and alchemical doctrines on the one hand and, on the other, the general cosmological and scientific background on which they stand, see the article on "Primitive Science, the Background of Early Chemistry and Alchemy," *Jour. Chem. Education*, 12: 3–10, 1935.

[8] Including, of course, its expansion into the two pairs of contraries of Aristotle and of the pre-Mosaic cosmologists.

[9] In the introduction and notes which accompany *Lu-Ch'iang Wu's* translation of the "Ts'an T'ung Ch'i" of Wei Po-yang, *Isis*, 18: 210–289, 1932.

larity between certain passages of the Chinese alchemist, Wei Po-yang, and passages of Zosimos and other Alexandrians—from which we wished to conclude merely that the Chinese and the Alexandrians both possessed a dualistic scientific background and that both had the mental habits of their times. From the evidence alone of this similarity, we are not willing to conclude, as Partington[10] wishes to do, that the Chinese and Alexandrian treatises and traditions are necessarily related at all closely or that one is derived from the other. Nor does the similarity of language prove a similarity of aim. The aim of the author is to be discovered in his statements. Because Wei Po-yang was writing of alchemy, it does not follow at all that Zosimos and the Alexandrians who used a similar language were also writing of it. If they were, it ought to be possible to find them saying so.

Quite another matter it is when we find that the "Speculum Alchemiae" of Roger Bacon describes a process for the preparation of the philosopher's stone identical with that which Wei Po-yang more than twelve hundred years earlier described for the preparation of the pill of immortality.[11] This is real evidence of the probable origin of European alchemy.

The ancient Egyptians had so many things that it would be extraordinary if they did not have alchemy. Partington[12] states that "Napier says the idea prevailed in ancient Egypt that gold was the only true metal, other metals being different varieties of and convertible into gold, an idea which persisted as alchemy, but gives no authority for this statement; the idea is almost the same as that of the Arabian alchemist Abu'l-Qasim al-Irâqi in the thirteenth century A.D." We must scrutinize the language carefully. If the Egyptians believed that other metals are artificially convertible into gold, then they believed in the truth of alchemy. Perhaps they believed, as the medieval alchemists did, that base metals in the earth are constantly undergoing a natural and spontaneous change or growth by which they are slowly converted into gold. The same idea appears in the writings of "Liu An" or "Huai-nan-tzŭ" (died 122 B.C.), the first Chinese who is supposed to have written on alchemy, by tradition a master of the art. Johnson,[13] says that he taught that "gold grows in the earth by a slow process, and is evolved from the immaterial principle underlying the universe, passing from one form to another up to silver and then from silver to gold." The belief that the conversion can be accomplished artificially is belief in the truth of alchemy, and the effort to bring it about by chemical means is the practice of alchemy. But there is at present no evidence that the ancient Egyptians were practicing the art. Indeed, the Alexandrians who had access to much of the culture of ancient Egypt do not seem to have practiced it.

In his recent book on "Alchemy, Child of Greek Philosophy," Professor Arthur John Hopkins defends two principal theses, first, that the Alexandrian chemists, or alchemists as he calls them, were interested in imitating the precious metals by alloying or by staining or tincturing base metals to the appearance of the noble ones, that they were interested in the color more than in the substance of

[10] Partington, *Nature*, 136: 288, 1935, says: "Many points of contact between these and other statements in the Chinese treatise and in the Alexandrian treatise can be found, so that the general conclusion of Dr. Wu and Professor Davis, who do not favor much relation, is scarcely borne out by detailed examination: they cite, in fact, several parallels with Zosimos in the notes and could have cited a good number more. These notes suggest parallels with later works on European alchemy . . ."

[11] *Isis*, 18: 243, 277, 1932.

[12] Partington, "Origins and Development," etc., p. 27, citing Napier, "Manufacturing Arts in Ancient Times," Paisley, 1879, p. 4.

[13] Johnson, "A Study of Chinese Alchemy," Shanghai, 1928, p. 75 *fn.*

the metals, and second that the theoretical basis of Alexandrian and of later European alchemy was derived from Greek philosophy, that alchemical theory arose out of the impact of the practical chemical arts of the Egyptians upon the speculative philosophy of the Greeks. The two points are not dependent upon each other. The first is one which Professor Hopkins has set forth clearly and convincingly in a number of earlier articles.[14] It appears to be fully established—and we shall devote no more space to it in the present paper, except to mention that the Alexandrian chemists, practicing the imitative arts of the earlier Egyptians, were well aware that their products were not the genuine materials. They no more thought their yellow alloys and tinctured metals to be real gold than we think German silver to be real silver or artificial silk to be identical with the product of the silkworm. If Hopkins's view is correct, then the Alexandrians were not practicing alchemy. There still remains open the question of the origins of that indubitable alchemy which the Arabs possessed and transmitted to the medieval Latins.

With the second of Professor Hopkins's contentions we are unable to agree. Since the Alexandrians had no alchemy, it seems improper to suppose that they had alchemical theory. They had chemical theories for their practical chemistry. They believed in the unity of matter, but it can not be maintained that that notion was original with the Greeks. They adhered to the idea-system of their time. For the interpretation of chemical phenomena they had theories which were based upon the ancient doctrine of the "two contraries." And that doctrine is much older than Greek philosophy. Having arisen in the darkness before known history, it gave rise to a persistent and uninterrupted stream of thought which flowed around, through and past the glory of Greek philosophy and dominated chemical thought—perhaps to the present—certainly to times as recent as those of Lavoisier and the Chemical Revolution.[15]

The medieval alchemists derived their alchemy from the Muslims, and our question becomes—Whence did the Muslims derive their alchemy? Evidently not from the Alexandrians. But they did derive from the Alexandrians the chemical art of changing the color of the metals, and apparently combined that art and its accompanying theory with the alchemical tradition, of the elixir and of real transmutation, which they derived from some other source. Both traditions are found in the Arab treatises and in the Latin writings which are based upon them, often confused but frequently in such fashion that they may be distinguished. In the tract "de Alchemia," which is ascribed to Albertus Magnus, the author says concerning alchemy that "through this art metals which are corrupt and imperfect in the mines are brought to perfection."[16] He says: "I began more diligently to keep vigil with the decoctions, sublimations, solutions, distillations, cerations, calcinations, and coagulations of Alchemy, and with many other labors, until at length I found the transmutation to be possible into sun (gold) and moon (silver) which are much better than any natural material in every test and hammering."[17]

[14] Hopkins, SCIENTIFIC MONTHLY, 6: 530–537, 1918; *Cairo Scientific Journal*, 11: 159–169, 1923; *Isis*, 7: 58–76, 1925; "Studien zur Geschichte der Chemie, Festgabe für Edmund O. von Lippmann," Berlin, 1927, pp. 9–14.

[15] Nierenstein, reviewing Hopkins's book in the *Journal of the American Chemical Society*, 58: 539, 1936, says: "There is no doubt whatever that the idea of transforming one form of matter into another is the logical consequence of Aristotle's philosophy of matter" (with which we agree fully), but adds—"and that the whole idea of ancient chemistry is imbued by the philosophy of Aristotle" (which is not the case by any means).

[16] "Theatrum Chemicum," Vol. II, p. 488, Ursellis, 1602.

[17] *Ibid.*, p. 486.

Although one may question whether the material which is better than gold in every test and hammering is really the same as actual gold, the passage nevertheless appears to assert the truth of alchemy. Another passage in the same work clearly represents the Alexandrian tradition. "All metals are transubstantiated into sun and moon which are equal in all respects to the natural materials in all operations, except that the iron of Alchemy is not attracted by the magnet and the gold of Alchemy does not gladden the heart of man, nor cure leprosy, and a wound festers which is made by means of it, a result which does not occur from natural gold. In all other operations, such as hammering and the test, it is like the natural material, and its color lasts forever."[18] The material which makes the festering wound is evidently brass or a similar alloy of base metals.

Arabic alchemy, and that of the later Europeans, contains other elements which were not derived from Alexandria. Professor R. Winderlich,[19] discussing the researches of Julius Ruska on the alchemy of al-Razi, says: "Alchemy as presented by al-Razi must have been preceded by a development that did not occur on Greek soil, for he uses substances, such as sal ammoniac, that were entirely unknown to the Greeks, and which for the most part bear Persian names. The logically thought-out theory of alchemy, firmly rooted in experiment, must have grown up in Persian soil." His evidence may indicate that alchemy came to the Arabs from Persia, but it certainly does not indicate that it originated in Persia. Perhaps it came to Persia from China.

The earliest alchemy with which we are acquainted is that which appeared in China in the third or fourth century B.C. It seems to have been of indigenous Chinese growth. The mystical philosophy of Taoism gave practical men a strong motive for wishing to prepare the pill of immortality. The dualistic Yin-Yang doctrine, which Liang[20] has shown did not prevail in the earliest Chinese thought but appeared full-grown at about the time that alchemy arose, evidently supplied a scientific background upon which alchemical theory and practice could flourish. The similarity of the Chinese doctrine to the doctrine of the "two contraries" which had existed at an earlier date in Egypt and in Mesopotamia suggests that the Chinese doctrine was an importation from one of these places.[21] It of course does not follow that alchemy was also an importation into China. While the doctrine of the "two contraries" led in the minds of the Alexandrians and later Europeans to a dualistic theory for the explanation of chemical phenomena, the same doctrine in the minds of the Chinese, who were not interested in chemical theory but were pursuing the practical end of preparing the pill of immortality, led to a theory of alchemy. Perfection of all kinds was to be procured by a proper balance of Yin and Yang. Wei Po-yang's process for the preparation of the pill of immortality, by the interaction of Yin and Yang in a closed container around which the fire, gentle at first and increased as the treatment advanced, was made to reverberate, is the same as that of the author of the "Speculum alchemiae," ascribed to Roger Bacon, for the preparation of the philosopher's

[18] *Ibid.*, p. 495.

[19] *Jour. Chem. Education*, soon to be published.

[20] Ch'i-Ch'ao Liang, "On the Origin and Evolution of the Doctrines of Yin-Yang and Wu-hsing" (in Chinese), *Eastern Miscellany*, Shanghai, Vol. 20, No. 10, pp. 70–79, 1923. Discussed in SCIENTIFIC MONTHLY, 31: 225 *ff.*, 1930, and in *Isis*, 18: 216 *ff.*, 1932.

[21] For a fuller discussion of the extra-Chinese origin of Yin-Yang and of the distinction between chemical and alchemical theory, see the article on "The Dualistic Cosmogony of *Huai-nan-tzŭ* and its Relations to the Background of Chinese and of European Alchemy," *Isis*, soon to be published.

stone from the sulfur and mercury principles.[22] There is no doubt of the general similarity between the methods and doctrines of the Chinese alchemists and those of the Muslims and later Europeans.

Since the Alexandrians had no alchemy, it is impossible that alchemy could have been imported into China from Egypt and unlikely that it was imported from Mesopotamia, where the dominant idea system was closely akin to that of Egypt and where, also, there is no evidence that alchemy was practiced. The possibility, however unlikely, is not excluded that alchemy may have been imported into China from India. At the same time the possibility remains open that Egyptian chemical knowledge and practices were imported into China, where the evident marvel of them led the Taoists to hope that they might supply means for the attainment of immortality. The similarity of the apparatus and reagents of the Alexandrian chemists and of the Chinese alchemists, the common interest in cinnabar and in mercury, are considerations which give plausibility to the speculation. Perhaps a knowledge of chemical behavior and of the equipment by which the behavior may be exhibited, controlled and applied came to China along with Yin-Yang from Egypt or Mesopotamia. But we must insist that the speculation applies to chemical knowledge and practice, not to chemical or alchemical theory. For the Chinese were not interested in chemical theory nor the Alexandrians in a theory of alchemy—and the dualistic chemical theory of the Alexandrians is later, perhaps several centuries later, than the dualistic alchemical theory of the Chinese. The similarities must be matched against the differences. The differences are evidences of a difference of origin for those portions of their respective doctrines and practices which differ from one another—and they appear to be precisely that the Chinese were pursuing the objectives of alchemy.

The Chinese alchemists were attempting to make real gold artificially, not because of its intrinsic value but because of its magical efficacy. They wished to procure longevity by eating food out of vessels which were made from it. They wished to compound from it edible pills of immortality by the eating of which they would be converted into *Hsien* or benevolent immortals. Such characteristically alchemical objectives were not pursued by the Alexandrians, who wanted the yellow imitation of gold because of its commercial value. The Chinese, wanting real gold for the compounding of the medicine, did not care whether the metal was of natural origin or resulted from the processes of alchemy: the two were identical. The notion that the noble metal itself was the material of the elixir seems to have survived in the motive which impelled the Arabs and medieval Latins to prepare an elixir of potable gold, but the later alchemists hoped only to procure longevity from it. Mohammedanism and Christianity promised them an immortality anyway. The notion of *Hsien* does not appear in European alchemy at all. But the extraordinary powers of the *jinni* of the Arabian Nights are so like those of the *Hsien* that we wonder whether the Arabic word *jinn* may not be derived from the Chinese *Hsien*.

Some of the dominant characteristics of Chinese alchemy are made clear by the following remarkable passages from Ko Hung's chapter on the Yellow and the White (trans. Wu), written about 317–332 A.D.

> It is another story with the *Chên Jen* (Men of Truth, Men Proficient in the Art, Sages). For they make gold with the purpose, not of getting rich, but of becoming *Hsien* by eating it. Therefore it is written in the Book, "Gold can be made wherewith people can be raised above this worldly life." Silver may be eaten for similar ends but is not as effective as gold.

[22] Discussed in the place last cited.

Then I asked further, "Why should we not eat the gold and silver which are already in existence instead of taking the trouble to make them? What are made will not be real gold and silver but just make-believes."

Said Chêng Chün in reply, "The gold and silver which are found in the world are suitable for the purpose. But *Tao-shih* (Seekers of the Way) are all poor; witness the adage that *Hsien* are never stout and *Tao-shih* never rich. *Tao-shih* usually go in groups of five or ten, counting the teacher and his disciples. Poor as they are, how can they be expected to get the necessary gold and silver? Furthermore, they can not cover the great distances to gather the gold and silver which occur in nature. The only thing left for them to do is to make the metals themselves.

"In that they are the essences of the medicines, the gold and silver made are superior to those found in nature. . . .

"The gold obtained by successful compounding is uniform inside and out. It may be put through a hundred workings without suffering any change. Therefore it is written in the formulas for its making that it may be made into nails. That shows its strength. Such results come of responsive infusion of the *Tao* (Way) of nature. Why should such deeds be called make-believes?

"Make-believes should be like the besmearing of iron with *Tsêng Ch'ing* (a blue compound of copper?) whereby the metal takes on a reddish sheen simulating copper, and the action of egg-white on silver to obtain a yellow coloring resembling gold. In all these cases there are merely external changes but no internal transmutations.

"The fungus *Chih* (Plant of Longevity) is a natural growth. But according to the *Hsien Ching* (Book of Immortals) it may be cultivated by means of the five stones and the five plants. The resulting plant will be exactly like that found in nature in the power of giving long life when eaten. The case is similar to the making of gold."[23]

The Chinese alchemist was well aware that there are chemical means by which the appearance of the metals may be changed, but insisted that the changes are merely superficial and are different from the real transmutations which he wanted and believed to be possible. We are not acquainted with anything like this in the writings of the Alexandrians and Byzantines.

Chinese alchemy and Alexandrian chemistry are alike in being erected upon a nature theory of the "two contraries," and alike very largely in the materials and apparatus with which they worked. They are utterly different in their objectives. It is probable that the dualistic philosophy came to China from Egypt or Mesopotamia, and it is possible that a considerable amount of chemical knowledge came with it. Alchemy evidently originated in China among the Taoists, who hoped by means of it to gain an immortality which their religion did not promise them. The evidence indicates that it came to Europe from China, presumably across Persia to the Arabs among whom the Chinese alchemical tradition mingled with the Alexandrian chemical one to form a body of doctrine which was transmitted to the Latins. In Latin alchemy, moreover, evidences of the two traditions are distinctly discernible.

[23] "An Ancient Chinese Alchemical Classic, Ko Hung on the Gold Medicine and on the Yellow and the White, the Fourth and Sixteenth Chapters of Pao-p'u-tzŭ translated from the Chinese by Lu-Ch'iang Wu with an Introduction, etc., by Tenney L. Davis," *Proc. Amer. Acad. Arts and Sciences*, 70: 221–284, 1935. Quoted passage, pp. 260–261.

THE WORLD'S FOOD AND THE ARGENTINE BIRTH RATE

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In 1923 Professor Edward M. East, discussing the world's food supply, suggested that the River Plate area would be "the last great temperate expanse of arable land to become sufficiently populous to forbid food exportation without a return in kind."[1] He believed that population increase in Argentina had not yet reached the point of maximum acceleration, assuming a continuance of free immigration, stable government and dominance of the Catholic faith. To-day Argentina is agitated over a declining birth rate, that has fallen with disturbing rapidity and regularity since 1923. Far from accepting this tendency as a factor that will lengthen its period as a supplier of food to international markets, many influential Argentine authorities are urging the adoption of a policy of stimulating immigration and redirecting the flow of migratory people to its ports so as to hasten the day when the home market will challenge the country's capacity to produce foodstuffs. This view is in such sharp contrast with informed opinion of the immediate pre-war period that it is interesting to note the underlying factors.

For some time previous to the outbreak of the world war Argentine economists had been viewing the heavy volume of immigration with considerable concern. The belief was gaining ground that the traditional policy of unrestricted non-selective entry had outlived its usefulness. During the period 1905–1913 immigration averaged 163,447 persons per year, compared with 47,788 in 1892–1904 and 51,864 in 1870–1891. Of even more significance than the volume was the fact that about 70 per cent. of the immigrants were male, over 65 per cent. unmarried, and over 50 per cent. between the ages of 21 and 40; children under 13 made up only 14 per cent. of the newcomers and persons over 60 less than 1 per cent. The large proportion of young able-bodied immigrants coupled with abundant economic opportunities to produce a very high birth rate. In the period 1910–1914 the annual birth rate was 37.86 per thousand; the natural increase of 20.78 during this time had few parallels among important nations. Foerster has demonstrated that the Italians who formed the largest single element in the new population were more prolific in Argentina than in Italy, and it is probable that the birth rate among foreign-born generally was higher than that of native Argentines.

Although the process of assimilation was facilitated by the preponderance of Latins, nevertheless it became increasingly difficult to absorb the immigrants economically; industrial adjustments were slow and in the meantime a problem in unemployment threatened. There was fear, too, lest national racial characteristics be submerged by the flood of foreigners. By June, 1914, the population included 5,100,000 native-born persons of European descent, 400,000 native-born with traces of Indian or Negro blood, and 2,300,000 foreign-born almost wholly European. Since the native population included women and children, while the foreign element was

[1] E. M. East, "Mankind at the Crossroads," p. 86. New York, 1923.

composed mainly of adults, the significance of these proportions is readily apparent.

It is not surprising, thus, that a movement to make immigration more selective arose. However, the war intervened to reverse the currents of migration. There was a net outflow of 214,175 persons in the six years 1914–1919. Thereafter Argentina regained its powers of attraction, and the flow of immigrants slowly advanced towards pre-war proportions. From 1920 to 1930 the net immigration was about 80,000 persons annually. But important changes occurred in the character of the inflow. The proportion of non-Latins increased from less than 15 per cent. to over one fourth of the total, and there was a slightly larger married group (30 per cent. in 1901–1910 and 40 per cent. in 1920–30).

The depression brought a number of new influences to bear on the Argentine economy. The prevailing spirit of nationalism and the general effort to attain self-sufficiency abroad cut down the markets for Argentine foodstuffs and reduced its purchasing power; the stream of immigration was once more shut off and in the four years 1931–1934 there was a net outflow of about 20,000 persons. This movement was especially important, because the emigrants were for the most part men of races easily assimilated, having trades or professions and of productive ages, while the recent immigrants are increasingly of less adaptable nationalities, such as Poles, Lithuanians, etc. Its markets reduced, Argentina too adopted the nationalistic philosophy. Great advances were made in the diversification of industry by the large-scale development of hitherto neglected crops, such as cotton and fruit, and by the growth of manufacturing. Economists began to make studies of the population needed to absorb the current industrial output and sought to learn what growth might be expected from the natural increase in population.

Little comfort was derived from the birth rate, however. It has fallen every year since 1923; the rate in 1934 was 25.0 per thousand, compared with 33.97 in 1923. The accompanying decline in the death rate from 14.79 to 11.50 was not sufficient to prevent a reduction in the natural rate of increase from 19.18 to 13.50. Since the tendency is for the urban population to gain at the expense of the rural (the percentage of population living in towns and cities of 2,000 population or over being 37.4 per cent. in 1895, 53 per cent. in 1914 and estimated at 60 per cent. in 1934), it is equally disturbing to find that the birth rate has declined even faster and to a lower level in the federal capital, which contains about one fifth of the total population. The birth rate in the federal capital fell from 34.09 in 1914 to 24.94 in 1924 and 18.12 in 1934. While the annual rate of increase of Argentine population was 3 per cent. in the period 1921–1925 it was only 1.4 per cent. in 1934.

Several factors have contributed to the decline in the birth rate. The decreasing influence of immigration is one. The absence of influential religious command is another, since the church is less powerful here than in certain other Catholic countries of Latin

TABLE I

GROWTH OF THE ARGENTINE POPULATION
(Rates per thousand inhabitants)

Year	Birth rate	Death rate	Natural increase
1915–19	33.94	17.12	16.82
1920	32.27	15.47	16.80
1921	32.75	15.78	16.97
1922	33.10	14.03	19.07
1923	33.97	14.79	19.18
1924	32.76	14.32	18.44
1925	31.76	14.11	17.65
1926	31.24	13.63	17.61
1927	30.78	14.11	16.67
1928	30.76	13.21	17.55
1929	30.24	13.83	16.41
1930	29.48	12.67	16.81
1931	28.50	13.38	15.12
1932	27.93	11.94	15.99
1933	25.90	11.61	14.29
1934	25.00	11.50	13.50

America. Military pressure such as puts a premium on the breeding of large families in some European countries is absent, too. In evaluating the economic factor it should be remembered that the unemployment problem in Argentina was relatively unimportant during the depression. Alejandro E. Bunge, the famous Argentine statistician and economist, accounts for this by three reasons. First, the fact that Argentina was under-built and badly in need of construction. Secondly, the diversification of industry; in 1933 the percentage of employed population in commerce, industry and agriculture-grazing was 12.1 per cent., 43 per cent. and 22.6 per cent., respectively, compared with 10.8 per cent., 38.5 per cent. and 27.2 per cent. in 1914; and this

TABLE II

RATE OF ANNUAL INCREASE IN POPULATION

Year	Rate
1915–19	1.37 per cent.
1920	2.19 " "
1921	2.50 " "
1922	3.11 " "
1923	3.71 " "
1924	3.09 " "
1925	2.59 " "
1926	2.70 " "
1927	2.77 " "
1928	2.59 " "
1929	2.50 " "
1930	2.37 " "
1931	1.79 " "
1932	1.66 " "
1933	1.49 " "
1934	1.40 " "

tendency continued in 1934 and 1935. Thirdly, the volume of exports of foodstuffs and raw materials was well maintained; export tonnage in the five years 1925–1929 totaled 75,041,000 tons, compared with 74,359,000 tons in 1930–1934.

It is clear that those who hope to reduce Argentina's dependence on foreign markets must be prepared to wait a long time if they count only on the vegetative population increase to expand the home market. The government is therefore being urged from many quarters to encourage immigration as one point in a general plan to organize a sounder national economy. Economic capacity to absorb a million immigrants, the argument runs, could be created by providing opportunities to purchase land, by organized colonization and by a break-up of the large estates; past efforts to effect such a reorganization of land ownership have amply demonstrated the difficulties. The further diversification of industry is also being sought. In addition, it is argued that the racial capacity to absorb such a large foreign element has changed vastly since 1914. Dr. Bunge estimates that in June, 1935, the composition of the population was as follows: native-born of European descent, 9,480,000; native-born with traces of Indian or Negro blood, 300,000; foreign-born, 2,500,000. In other words, while in 1914 the native population was little more than double the foreign, it is to-day about four times as numerous.

The rate of natural increase of the Argentine population still exceeds that of other leading nations on the continent, of nations formerly supplying man-power to the River Plate and of the great grain-export competitors. For instance, the rates in 1931–32 compared as follows: Argentina 16, Chile 11.4, Italy 9.4, Canada 12.5, Australia 8.3. But there is no denying that unless public opinion forces the government to take the strenuous measures that will be necessary for attracting immigrants on a large scale, the declining birth rate has definitely extended the period during which Argentina may be relied upon to furnish food for over-populated areas.

CONSERVATION AMONG PRIMITIVE HUNTING PEOPLES

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THE hunting and gathering of primitive non-agricultural peoples was not a hit-or-miss random search for plant and animal food and industrial materials.

Dependent upon naturally limited resources in a limited territory for themselves and their descendants, they took stock of their limited resources. They knew in detail just what the supply of each thing was—wild grasses, berries, roots, animals, trees—and knew where each was to be found when wanted and in approximately what quantity. Thus, for the Australian aborigines of North Queensland Roth wrote:

> Independently of the greater or less extent of country over which the community as a whole has the right to hunt or roam . . . there are definite territorial divisions, certain tracts of country for each family, each such tract bearing a distinctive name. In the same way that a European knows what vegetables, shrubs, or flowers are growing in his garden, so do the natives have a fair idea of the amount of any special growth of edible fruits, seeds, or roots, as well as the particular haunts of the various animals and birds found in their particular piece of ground.[1]

And of the northeastern Algonkian Indians and their family hunting territories Speck writes:

> Economically these territories were regulated in a very wise and interesting manner. The game was kept account of very closely, so that the proprietors knew about how abundant each kind of animal was, and hence could regulate the killing so as not to deplete the stock."[2]

A hunter can "tell at any time the number of animals which he can dispose of each year in the district without endangering the supply.[3]

[1] W. E. Roth, North Queensland Ethnography Bulletins, No. 8, p. 8, Brisbane, 1900.

[2] F. G. Speck, Memoir 70, Canadian Geological Survey, p. 5, Ottawa, 1915.

[3] F. G. Speck, *Old Penn Weekly*, p. 185, University of Pennsylvania, 1914–15.

The pressure of population upon resources made for intensive exploitation of the limited stock of resources. Of the Hopi, for example, we are told that "there is almost no plant which the Hopi does not use in some way," and "every berry patch for miles around is known and visited." Our increasing number of exhaustive volumes on primitive ethnobotanies affords wide-spread examples of such intensive use of wild resources. Of the Hupa ethnobotany, for example, we read that "They seem to have discovered and made use of every vegetable fit for food, and in two instances have learned to render poisonous plants harmless."[4]

Out of such a background of natural limitation of supply, pressure of population on the limited supply, a thorough inventory and intensive exploitation, one might expect that purely economic motives might lead to a conservation of those elements of the supply which experience would show would diminish and tend to disappear if conservation were not applied. However, some of the facts available on the subject suggest that spiritual motives may have played a large part in giving rise to conservation. To primitive man there is soul in all things animate and (to us) inanimate.

The primitive hunting Yukaghir of northeastern Siberia, for example, in hunting the wild reindeer always took care to leave some of a herd for breeding; and in closing a stream with a cross weir part of the fish were always allowed to pass first that they might spawn. Wasteful killing of animals was taboo. They appear to have rationalized their rude conservation in spiritual terms, however. To explain why the elk disappeared from a certain region they tell

[4] W. Hough, *American Anthropologist*, 1897.

a tale which explains that the spirit of the elk disapproved of a case of wasteful killing of elk.[5] An almost identical tale is told by the Micmac Indians of an island off Nova Scotia to explain the disappearance of the moose from their particular area. After an improvident killing of moose the remaining moose, offended, left the island, never to return.[6] The Kwakiutl Indians of Vancouver Island,[7] in peeling bark from cedar trees for the various important industrial uses to which this bark was put, never stripped off all the bark of a tree, "because the young cedar tree would die and then another cedar tree nearby would curse the bark peeler so that he also would die." And the taking of any bark at all from a tree must be propitiated. The bark peeler stands before the tree, uttering humble apologies and explaining the necessity of taking some bark.

Speaking of the Ojibway, a literate Ojibway himself writes:

> In addition to the belief in the immortality of their own souls, they suppose that all animals, fish, trees, stones, etc., are endued with immortal spirits and that they possess supernatural power to punish any one who may dare despise or make any unnecessary waste of them. . . . In their heathen state they very seldom cut down green or living trees, from the idea that it puts them to pain; and some of their powwows have pretended to hear the wailing of the forest trees when suffering under the hatchet or axe.[8]

But whether or not in its origins conservation was of spiritual motivation among some or all peoples who have practiced it, or whether the spiritual attribution is a mere rationalization or adventitious association with the practice, nevertheless, once instituted, conservation becomes an economic practice and the tribal technology is adjusted to it; it becomes one aspect of their "state of the arts" which could not be discontinued without a diminution in food and other supplies. And it is a fact that our more important references to conservation among primitives do not carry any reference to anything involved except economic expediency. These references we shall now turn to.

Among the Choctaw of the southeastern United States in their old home in Mississippi, for hunting, the tribe broke up into families and left the village to go off into the woods for the regular hunting seasons. Laws were enacted first, "governing the amount of game that might be killed by each family on the five rivers, and how much by the whole band or okla." Every month each band chief was required to report to the head chief just how much had been killed by each family under his control. Besides conservational regulation of quantity there were laws confining hunting of one type of game and another to proper seasons and in proper places, laws even controlling fish poisoning and spearing.[9]

Among the Mahickan much farther north:

> It was a law among them not to kill any more game than was necessary for their own use, none even to barter, which might have produced a temptation to waste their animals. By these regulations their game was preserved undiminished, the consumption being no greater than the natural increase. This law continued in force until the Chuckkathuk or white people came to this island.[10]

[5] W. Jochelson, Jesup Expedition, Memoirs of the American Museum of Natural History, Vol. 10, pp. 146, 148, 150, 1910.

[6] F. G. Speck, Beothuk and Micmac, Indian Notes of the Heye Museum of the American Indian, p. 115, 1922. For general considerations see F. G. Speck, "Naskapi" (Chapter 5 on "Animals in Special Relation to Man"), 1934.

[7] F. Boas, 35th Annual Report of the Bureau of American Ethnology, 1913–14, pp. 616–619. In the Documentos Ineditos . . . Espana, Vol. 104 pp. 159–60 (Manual de Jacinto de la Serna) is a similar Aztec prayer assimilated to Catholic ritual.

[8] P. Jones, "History of the Ojibway," p. 104, 1861.

[9] J. R. Swanton, "The Choctaw," *Bulletin* 103, Bureau of American Ethnology, pp. 54, 101, 1932.

[10] A. Skinner, "Mahickan Ethnology," Milwaukee Museum Publications, Vol. 2, 1925 (from a Manuscript of 1822).

Among the still more northern hunting Algonkians what amounts almost to game farming appears, evidenced in the accounts of Speck, Davidson, Hallowell and Cooper among the various bands. The native owner of a family hunting tract explains:

> The beaver is the Indian's pork; the moose, his beef; the partridge, his chickens; the caribou or red deer, his mutton. All these formed the stock of his hunting ground, which would be parcelled out among his sons when the owner died. He would say to each of his sons: "You take this part; take care of this tract; see that it always produces enough."

Beaver was made the object of the most careful "farming"; the numbers of occupants, old and young, to each "cabin" of the animals was kept account of; breeders were not killed; each year only young or very old animals were slain. In certain districts moose or caribou would be protected during one year; in other districts during the next year. Some proprietary families went so far as to divide their own territories up into quarters around a center, "hunting in a different quarter each year and leaving the tract in the center as a reserve to be hunted over only in case of shortage from the exploited tract."[11]

A conservation practice which might conceivably have led on to the development of agriculture was observed by Curtis among the Kwakiutl of northern Vancouver Island.[12] Among them, clover beds, like other lands, are held within families, and were particularly valuable because clover roots were a high-priced luxury, being considered indispensable to good health. "For this reason the land is well cared for. The main root stocks are never taken, and such pieces as are not deemed good for food are put back into the ground. This is the nearest the Kwakiutl ever approached to agriculture."

The supply of firewood was vitally important to the Indians. Consuming all the wood so available within a practicable distance of a settlement would necessitate moving the settlement with resultant great disadvantage; this was as much a cause of village removals as was weed infestation of farms among the agricultural tribes. One note of conservation is available with reference to firewood and to bark and wood used industrially in an area where such would be particularly important. An Anvik, Alaska, Indian told an ethnologist that "in getting wood or brush from the forest we do not take all there is in any one place. We depend on the wood or bark. If we destroyed it, we would become vagabonds."[13]

That conservation is aboriginal, prior to European influence, where we find it, might be brought in question, but there seems to be no doubt of its aboriginality. The Choctaw and Mahickan data I have already cited are for the pre-White period, though reported later. And Cooper[14] found among the James Bay Cree that white influence was breaking down the native conservation. Speck[15] in his Mistassini investigation affords evidence that the practice antedated the coming of the fur-trading companies to the northern woodlands and tundras.

[11] Speck, Memoir 70, Canadian Geological Survey, p. 189, Ottawa, 1915, and *Old Penn Weekly*, p. 5, University of Pennsylvania, 1914–15. See also his "Lake St. John Family Hunting Territories," *Anthropos*, 1927; "Mistassini Family Hunting Territories," *American Anthropologist*, 1923; and "Oka Family Hunting Territories," *Ibid.*, 1926. Also the data on conservation in D. S. Davidson, "Waswanipi Family Hunting Territories, Indian Notes, Heye Museum, N. Y, 1928; and "Notes on Tête de Boule," *American Anthropologist*, 1928.

[12] E. S. Curtis, "The Kwakiutl, p. 43, 1910.

[13] E. C. Parsons, "The Dene of Anvik," *Anthropos*, p. 68, 1920; *Cf.* W. C. MacLeod, "Fuel and Early Society," *American Anthropologist*, 1925.

[14] J. Cooper, "James Bay Cree," *American Anthropologist*, 1930.

[15] F. G. Speck, Memoir 70, Canadian Geological Survey, p. 459, Ottawa, 1915.

Dunn in 1842 would seem to imply that the northern woodlands Indians were taught conservation by the fur companies;[16] but Harmon was in the same western country many years before Dunn.[17] He was the first white man among the Carrier Indians of the western plateau, and found conservation there among them, quite without the possibility of fur company influence. Incidentally, he also found private or family ownership of hunting lands, another thing general among the hunting peoples of North America which some skeptics have thought might be a result of white influence. The fact is that the natives of the northwestern woodlands had sometimes to struggle against the breakdown of their conservation system from some fur-trading influences. About 1811 "free hunters," including a band of Iroquois detached by the fur trade, entered the northwest country and killed beaver recklessly. As a result they incurred the hatred of the Piegan, Cree and other natives of the region because of the diminution of the numbers of beaver.[18] Back in their own country over a century and a half earlier the Iroquois, however, were conservationists, as evidenced by their statement of the cause of the war between them and the Eries. La Hontan writes that the Iroquois made war on and exterminated the Eries because they had trespassed on Iroquois territory and "had acted contrary to the customs of all Indians, for they had left none of the beavers alive; they killed both males and female."[19] The Eries were exterminated in the 1630's, a time when the fur trade was just having its effect in this area.

[16] J. Dunn, "History of Oregon," p. 65, 1842.

[17] D. W. Harmon, "Journal," (1810–19).

[18] Dunn, p. 65, and D. Thompson, "Narrative," (1784–1812), Champlain Society Publications, pp. 205–6, 553, 1916.

[19] La Hontan, "Voyages" (1682–1703), 2 vols.; 2nd ed., 1725; Reprint Vol. 2, p. 62, 1922.

Some Possibilities in the Data

The above appears to be all that is available on conservation among primitive hunting peoples, but the absence of other note of it may mean merely that the subject has not been inquired into in the field. If and when new data are available it may be possible to reach some interesting conclusions concerning the place of conservation in the economic development of primitives. In conclusion, we may mention just two of the possibilities.

Meeting with the data, orginally, it struck me that the functional relationship between land tenure and conservation would appear to indicate that family or private ownership of hunting lands (and such is universal among pre-agricultural hunters) was a necessary prerequisite of conservation. But upon discovering the Choctaw data, this seems ruled out, for we have no evidence that the Choctaw, who were agriculturists, too, although hunting was important among them and they were sellers of meat to other agricultural tribes, had family division of the hunting grounds. The Choctaw facts indicate that tribal political control could effect conservation without private ownership and management.

It occurred to me, also, that conservation practice may have been the practice which led to the development of domestication of plants and of animals. Aside from the dog (kept originally as a pet, perhaps) the reindeer appears to have been the first animal domesticated by man, and this occurred in sub-boreal Asia.[20] Since our data on conservation is largely for the adjacent sub-boreal hunting cultures of North America, perhaps one may consider it possible that a conservation technique played its part in the original reindeer domestication whatever part the keeping of pets or

[20] According to the well-considered investigations of Flor and Koppers of Vienna.

animals for sacrifice may have played in other domestications. However, as for plant domestication, my own study of the motivations underlying certain important plant domestications leads me to doubt that any plant domestication ever evolved from an extension of the conservation technique.

UNITED STATES AND BRITISH UNITS OF WEIGHTS AND MEASURES[1]

By HENRY W. BEARCE

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THE weights and measures units in commercial, industrial and ordinary every-day use in the United States are often referred to as the English or customary units, as distinguished from metric units, and they are generally assumed to be the same as the corresponding units in use in Great Britain. While in general this assumption is correct, there are a few important exceptions.

The U. S. yard and the British yard, while differing slightly in basic definition, are essentially equal for all practical purposes except the most precise linear measurements. The various multiples and subdivisions of the yard are also essentially equal. Similarly, the U. S. avoirdupois pound and the British Imperial pound are substantially equal, although differing slightly in basic definition. On the other hand, the U. S. bushel, gallon, quart and fluid ounce are quite different from the British units of the same names. Of these, the units of volume, as applied to liquids, are perhaps most often confused.

The U. S. gallon is defined as a volume of 231 cubic inches; the U. S. liquid quart as 1/4 U. S. gallon, or 57.75 cubic inches; and the U. S. fluid ounce as 1/32 U. S. liquid quart, 1/128 U. S. gallon or 0.2256 cu. in.

[1]Published by permission of the director of the National Bureau of Standards.

The British (Imperial) gallon is defined as the volume of 10 pounds of water, under specified standard conditions of temperature and pressure. It is equivalent to 277.420 cubic inches. Thus the British gallon is larger than the U. S. gallon by slightly more than 20 per cent.

The situation with reference to the measurement of volume of liquids, in terms of U. S. and British units, is further complicated by the fact that the relation between the gallons does not hold for certain subdivisions of the gallons. For example, while both gallons are subdivided into quarts, fluid ounces and drams, the method of subdivision is not the same in all cases, and while the same relation holds between the quarts as between the gallons, it does not hold between the fluid ounces or between the drams. This arises from the fact that while in each system of units 4 quarts make 1 gallon, and 8 drams make 1 fluid ounce, the quarts are not divided into fluid ounces in the same way. In the U. S. system the quart is divided into 32 fluid ounces, while in the British system the quart is divided into 40 fluid ounces. The relations of the units of the two systems, arranged in tabular form, are as follows:

U. S. System	British (Imperial) System
8 fluid drams = 1 fluid ounce 32 fluid ounces = 1 quart (liq.) 4 qts. = 128 fl. oz. = 1 gal. = 231 cu. in. = 8⅓ lb. of water (approx.)	8 fluid drams = 1 fluid ounce 40 fluid ounces = 1 quart 4 qts. = 160 fl. oz. = 1 gal. = 277.420 cu. in. = 10 lb. of water at 62° F.

From the relation shown in the above table it is found that while the British gallon and quart are larger than the corresponding units of the U. S. system, the British fluid ounce and dram are smaller than the corresponding units of the U. S. system.

The relations[2] are:

1 British (Imperial) gallon = 277.420 cu. in.
= 1.20095 U. S. gallon

1 British (Imperial) quart = ¼ gallon (Imperial)
= 69.355 cu. in.
= 1.20095 U. S. liq. quart

1 British (Imperial) fluid ounce = 1/40 Imperial quart
= 1.7339 cu. in.
= 0.9608 U. S. fluid oz.

1 British (Imperial) fluid dram = ⅛ Imperial fluid oz.
= 0.2167 cu. in.
= 0.9608 U. S. fluid dram

1 U. S. gallon = 231 cu. in.
= 0.83267 Imperial gal.

1 U. S. quart (liq.) = ¼ U. S. gallon
= 57.75 cu. in.
= 0.83267 Imperial quart

1 U. S. fluid ounce = 1/32 U. S. quart (liquid)
= 1.8047 cu. in.
= 1.0408 Imperial fl. oz.

1 U. S. fluid dram = ⅛ U. S. fluid ounce
= 0.2256 cu. in.
= 1.0408 British fluid dram

The difference between U. S. and British units of the same name, as shown in the above table, sometimes leads to uncertainty and confusion in the measurement of volumes of liquids and in the interpretation of markings on containers of liquid commodities. The situation is particularly troublesome in the case of products bottled and labeled in one country and subsequently shipped into and sold in another country; as, for example, in transactions between residents of the United States and Canada.

It is reported that an American motorist, on her return from Canada, remarked that she had found Canadian motor fuel superior to the U. S. product as regards miles per gallon. Had she carried her observations further she would have learned, no doubt, that in Canada her tank did not hold as many gallons as she was accustomed to putting in it at home and that she paid more per gallon in Canada than at home.

Sellers of imported bottled products are not always above suspicion in the matter of interpretation of markings, and newspaper advertisements of such products as wines and liquors are sometimes misleading. For example, a Washington newspaper not long ago carried an advertisement in which certain Canadian products were listed as "Canadian quarts," "full Canadian quarts" and "Imperial quarts." As a matter of fact there is, of course, no such unit as a "Canadian quart" or a "full Canadian quart," as distinguished from the British or Imperial quart. The bottles advertised were, in all probability, short measure "fifths," full measure "fifths" and Imperial quarts, respectively (a "fifth" being 1/5 gallon).

A point already mentioned that should be kept in mind, in relation to U. S. and Canadian liquid measures, is that the Canadian, British or Imperial fluid ounce, instead of being 20 per cent. larger than the U. S. fluid ounce, as is the case with the gallon and quart, is about 4 per cent. smaller than the U. S. unit of the same name. That is, in order to be equivalent, Canadian and U. S. prices per quart and per gallon should be in the ratio of 120 to 100; and prices per fluid ounce should be in the ratio of 96 to 100.

Let us turn now to the British and U.

[2] The relations given herein are correct to the decimal places given; they should not, however, be taken as exact.

S. bushels. The British bushel is defined as 8 Imperial gallons, which is equivalent to 2219.36 cubic inches, and the U. S. bushel is defined as 2150.42 cubic inches. That is, the British bushel is larger than the U. S. unit of the same name by about 3.2 per cent. The British bushel is divided into 32 quarts of 69.355 cubic inches, while the U. S. bushel is divided into 32 dry quarts of 67.20 cubic inches. Thus the British (Imperial) quart, which is used for both liquid and dry commodities, is larger than the U. S. dry quart by 3.2 per cent., while it is larger than the U. S. liquid quart by 20.1 per cent.

Now just a word about pounds and tons. As already stated, the British and U. S. avoirdupois pounds are practically equal; but in the United States 100 pounds make 1 hundredweight, while in Great Britain the hundredweight is 112 pounds or 8 "stone" of 14 pounds. Similarly, the ton in the United States is usually 20 hundredweight, or 2,000 pounds, while in Great Britain it is 20 hundredweight of 112 pounds each or 2,240 pounds. (The "long ton" of 2,240 pounds is used to some extent in the United States, especially in the coal industry, while the "cental" of 100 pounds is used to some extent in Great Britain.)

It is seen from the foregoing that although our customary weights and measures units are in many cases the same as the British units of the same name, they differ rather widely in certain other important cases.

PLANKTON AND INVERTEBRATES OF THE ANTARCTIC

By DR. EARLE B. PERKINS

ZOOLOGICAL LABORATORY, RUTGERS UNIVERSITY; ZOOLOGIST, BYRD ANTARCTIC EXPEDITION II, 1933–1935

WHEN the second Byrd Antarctic Expedition left Boston on October 11, 1933, for extensive explorations and scientific investigations in the Ross Sea Dependency and Marie Byrd Land, the biological staff had outlined a rather elaborate program. This included work on bacteria, plankton, such invertebrates as were likely to be met with, the relatively few fishes and the penguins and seals which are so typically Antarctic. Further, a collection of algae, lichens, mosses and microscopic life in the fresh water pools was to be made by the sledging parties going to the mountains, and the skins of birds and seals procured for study and museum display. In addition to bringing back preserved specimens it was the hope of Admiral Byrd and the biologists that live seals and penguins could be brought to the States for further study of their physiology and behavior.

It is gratifying to find in summarizing the accomplishments of the expedition that a great deal of the original program has been carried out. This is particularly noteworthy in view of the many difficulties which were encountered in a region so remote and where unfavorable weather conditions and environmental handicaps greatly impeded activities. Studies and collections were made in every phase of the biological work as outlined in the beginning, and when finally presented in the published reports and as museum specimens will amply justify the inclusion of a biological program in the work of a polar expedition.

This preliminary account of studies on invertebrate life and the composite plank-

ton represents only that part of the program with which I was primarily concerned, the other phases of the investigations being presented separately by those members of the staff responsible for them.

Plankton

This includes the zoo- and phytoplankton collected and photographed during the two crossings of the Pacific, within the Antarctic Circle, the Ross Sea and the Bay of Whales. Collections began shortly after leaving Panama and were carried on with but few interruptions to Easter Island, and then followed a great circle course to Wellington, New Zealand. This was over a route infrequently traveled. Within the Antarctic Circle the ship pushed eastward through unknown waters to the 118th meridian. Collections were made in this interesting area of icebergs and pack ice where no ship had been before, as well as over the return course to the Ross Sea.

At Little America there was little opportunity for extensive collections because of unfavorable weather conditions and heavy ice. Several hauls were made, however, through the bay ice during the period of darkness, as well as rich collections from upturned blocks of ice which were deeply colored with many species of diatoms. As soon as ice conditions permitted, in December, 1934, vertical hauls were made with the plankton net through cracks in the bay ice at as frequent intervals as weather conditions permitted. This was continued until the arrival of the ships late in January, 1935, when the work was carried on aboard the S.S. *Bear of Oakland* in the Ross Sea, and on the passage to Dunedin. From there a continuous series of samples was taken aboard the S.S. *Jacob Ruppert* at 50-mile intervals across the southern Pacific to Panama, via Easter Island, by allowing a stream of sea water from the main circulating pump to run through the net. In all cases records were kept of temperatures and salinities, and a complete photomicrographic record made of the many species obtained—the photographs being made before the preservative had altered the appearance of the specimens. In some cases where the material warranted it, cinemicrographs were made of active specimens. This was of particular interest in connection with living rotifers, tardigrades and protozoans brought back from the Edsel Ford Mountains in Marie Byrd Land and from the Rockefeller Mountains.

Pending the completion of the task of identifying the many species found in the plankton very little can or should be said concerning them, other than to state the character of the hauls in a general way. The following is a brief review of the nature of the plankton samples in the wide range of areas covered.

South Pacific, November–December, 1933. The vast majority of organisms obtained consisted of many species of copepods with striking variety as to size, shape and color. Also making up a large part of the catches were diatoms, dinoflagellates, radiolarians, heliozoans, colonial hydroids, Sagittae, a few annelids, pteropods and other small gastropods, including a pelagic nudibranch. During the afternoon of December 1, in Latitude 38° 30′ South—Longitude 169° 45′ West, large brown patches were seen in the water for the first time, varying in size from a foot or two square to about 25 by 200 feet, all with sharply defined edges. Plankton samples taken during this time contained vast numbers of Peridinium, not hitherto seen.

Between November 21 and November 29 only two samples were retained because of the nearly complete absence of plankton in the filtered water. This was along the 33rd parallel between 122° and 161° west longitude in a zone of rapid change of water temperature. On November 20 the water temperature was

19.2° C. and on November 29 it had dropped to 16° C. At this colder temperature and beyond the transition zone the plankton became abundant again.

On the whole, the amount and variety of life in the samples taken, considering the great volume of water filtered, is relatively small compared to the planktonic "soup" so easily obtained in colder waters. Nevertheless, the collections are of considerable interest because they were made in a region far removed from the usual paths of ships across the Pacific.

Antarctic Seas. With rapidly falling water temperatures on the voyage to the Ross Sea from New Zealand, there was the expected change in the character and abundance of plankton. Whereas copepods and other small crustaceans had been the most conspicuous feature of warmer waters, with temperatures lowering rapidly from 10° C. out of New Zealand to – 1.5° C. in the pack ice, the algae became dominant to the eventual exclusion of all other forms of life at the surface. Myriads of these organisms were caught at each haul of the net, representing many different species. Pack ice and the water line of bergs and ice islands were conspicuously stained a yellowish-green by the countless numbers of these unicellular plants.

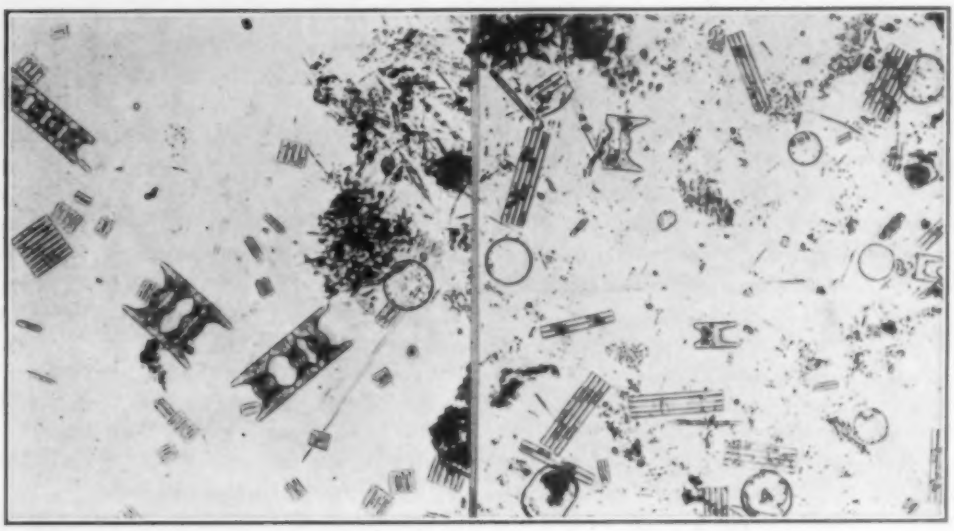
Bay of Whales. After construction of the laboratory at Little America and the major part of establishing the winter camp had been completed, work was resumed on the plankton of the Bay of Whales. The first successful haul was made on April 9, 1934. The newly formed bay ice was then about two feet thick. A vertical haul of 300 feet yielded an abundance of copepods and a few diatoms. There were also several specimens of living globigerina and radiolaria. A block of ice from the bottom layer of the newly formed bay ice contained several types of diatoms which had become trapped as the water froze. At the same time a piece of plankton-colored ice from an upturned piece of pressure ridge was brought back to the laboratory and found to contain a highly concentrated mass of phytoplankton.

On April 17 another plankton haul was made, this time from the bottom at 330 fathoms. Mud adhering to the weight contained many shells of foraminifera and a few nematode worms. Copepods and a few spindle-shaped diatoms were brought up in the net, as well as several radiolarians.

The next haul was on May 15 through four feet of ice. The net was drawn up from 800 feet and was highly luminescent from the many copepods captured. These continued to emit light for some time after being brought back to the laboratory. The sample also contained several types of diatoms, radiolarians, many small gastropods and some algal fragments.

After the sun disappeared on April 19 the amount of daylight at noon diminished rapidly so that the work was done in the darkness of the winter night and under severe temperature conditions. Getting a hole through the ice became a considerable problem, and handling the net to drain the sample before it became frozen required rapid and sometimes painful work. Every hope was held, however, for the continuation of the collections so that the changes in the plankton could be followed through the period of darkness. After chopping through five feet of ice on May 28 a successful haul was made from 700 feet, with the expected results. There were no diatoms present, but many copepods—a few being about 4 mm. long.

During the height of the Antarctic summer the diatoms reign supreme in the upper regions of the water. In the Bay of Whales a single vertical haul from a depth to which light penetrates will bring up countless numbers of individuals rep-



PHYTOPLANKTON TAKEN FROM THE BAY OF WHALES.

resenting a score of species. These algae reproduce at an amazing rate during the period of constant daylight and serve as food for hosts of animals. As the winter night approaches there is insufficient light for them to carry on their photosynthetic activities and they disappear. But the animal life continues, subsisting upon the remains of the algae, suspended organic material and stored food reserves. In the frigid depths of the bay, under a dozen feet of ice, and in the darkness of the winter night there live vast numbers of organisms defying what seems to us the most inhospitable climate in the world. Actually, however, except for the nearly complete absence of light in the upper regions of the water their environment has not changed since summer, when the blazing sun drove millions of tons of ice out of the bay. The water temperature remains very close to the freezing point throughout the year, and with sufficient food materials present animal life is able to continue even without light. The low temperature reduces organic decomposition to a minimum, so food is abundant, yet it is an expensive diet. The supply is limited because no more is being produced. The invertebrates are living on others of their kind; the fishes are eating the crustaceans; the seals, as long as they can find a place to breathe, are living on the fish and crustaceans, dependent upon the return of the sun—and the diatoms.

Another haul was started on June 28, but due to the extremely low temperatures the hole was not completed until the 29th. At that time the temperature was – 52° F. with a 15-mile wind. Working by lantern light in the bottom of the hole was awkward and the water rushed up before a suitable opening had been made. When later cleared with a long-handled chisel, it was found impossible to get a net through the underlying mush and crystals. A 15-foot pole did not reach through to clear water. This dense layer of crystals formed under the solid ice effectively stopped further plankton work, and the studies on plankton distribution through the period of darkness had to be abandoned.

After the return of the sun on August 22 plankton work and all other collections

near Little America were greatly handicapped because of ice conditions. Although seal holes were easily reached and appeared to offer a likely place for lowering the net, it was soon found that invariably there was a thick layer of ice at depths of from ten to fifteen feet beneath the surface which prevented the further descent of the net. A few copepods were obtained, however, by bailing water through the net from the surface. Pieces of meat suspended in the holes attracted numerous amphipods. An unsuccessful attempt to blast a hole through the thick bay ice resulted only in filling the hole with broken ice, mush and crystals. The first successful catch was made through a large crack which appeared in December. Vertical hauls from 300 feet were made every day that the weather permitted. Several Euphausia, amphipods and a few small medusae were obtained with a dip net. On the whole there was a disappointingly small amount of plankton obtained because of the difficulty of getting the net into clear water.

With the arrival of the *Bear of Oakland* in the Bay of Whales on January 19, 1935, every opportunity was once more afforded to obtain plankton. A laboratory was set up on board with full facilities for collecting and photographing. Vertical and horizontal hauls brought in a rich collection, chiefly diatoms. Many of these were in the process of division. When a scrim net one meter in diameter and four meters long was towed for one-half hour at the rate of about one knot, an astounding mass of phytoplankton was obtained, completely filling a gallon jar with the thick "planktonic soup." The collecting of plankton was continued for several days at the opening to the Bay of Whales, in the Ross Sea within a radius of 20 miles from the bay, westward along the Ross Barrier to Discovery Inlet, and then northward out of the Ross Sea to New Zealand.

South Pacific, March to April, 1935.

MAKING MICRO-MOVIES OF LIVING PLANKTON.
DR. E. B. PERKINS IS SHOWN IN HIS LABORATORY AT LITTLE AMERICA.

Continuous plankton collections were made from Dunedin to Panama, via Easter Island and the Galapagos Islands, by filtering a stream of sea water led off from the main circulating pump in the engine room. The ship's sea water intake is about 15 feet below the surface and the outlet to the plankton net about 10 feet from the ship's side. The arrangement was a good one—delicate organisms were not crushed and there was no rust nor scale to interfere with the routine examinations. The plankton bucket was emptied on the average of three times daily, some hauls being taken during daylight hours and some during darkness in order to bring out diurnal variations. A great variety and abundance of plankton was obtained which, as a complete series of stations at short intervals across the South Pacific, should be of considerable interest.

Beginning on the evening of March 24 at Lat. 42° 40′ S. Long. 141° 06′ W. and lasting for four days to Lat. 39° 05′ S. Long. 129° 45′ W. there was a spectacular display of the colonial ascidian Pyrosoma. As far as the eye could reach the sea was swarming with these highly luminescent organisms. Some of them were of huge size, being approximately 18 inches long and 5 inches wide.

The plankton collected on this second crossing of the Pacific was perhaps the most interesting of all because of the great variety of forms and the change in general character of the catch during the long, slow voyage. Copepods, of course, were the most numerous, but the variety of form and delicacy of coloring made them of never-failing interest and good photographic subjects. Salps, small polychaetes, pteropods, decapods and other small macrurans in abundance, radiolarians, peridinians and a host of other organisms made the thrice-daily collection an event in the day's routine.

Dredging—Bay of Whales

While the *Bear* was waiting for the ice to go out of the bay so that supplies

COLLECTING AMPHIPODS.

SEAL HOLE USED FOR PLANKTON COLLECTIONS, BAY OF WHALES, ANTARCTICA.

could be loaded for the return voyage, there were several opportunities for dredging. The first haul was made on January 22, the dredge being shot in 540 meters of water between East and West Capes. The dredge brought up one complete crinoid and several stalks, four holothurians and several species of polychaetes—some with complete mud cases. Much blue and yellow clay and many stones were brought up in the dredge. Bottom deposit samples were kept. Another dredging from 480 meters off West Cape, where the bottom is rocky and slopes upward to the ridge which parallels the Ross Barrier, brought up tunicates, lamellibranchs, many small sponges, polychaete and sipunculid worms, colonial bryozoans, asteroids and ophiuroids. Off East Cape the list of bottom animals at a depth of 490 meters includes polychaetes, tunicates, holothurians, pycnogonids, a large sponge, bivalve mollusks and brachiopods. Other hauls with the dredge in the vicinity of the bay brought much the same variety of animal life. The bottom life is exceptionally rich and well worth investigating further.

The collections obtained, both plankton and dredge hauls, have had a preliminary examination, and the most characteristic or unusual forms have been photographed. Critical examinations have, of necessity, been deferred until a later time, when descriptions of the collections will be made available.

THE PROGRESS OF SCIENCE

THE CHRISTMAS MEETING OF THE AMERICAN ASSOCIATION

ATLANTIC CITY is to be host to the American Association for the Advancement of Science and Associated Societies for the ninety-ninth meeting, which will be held in the week from December 28 to January 2, 1937. Only one meeting has been held in Atlantic City previously, and that occasion was voted most successful. The large, well-planned and recently renovated Municipal Auditorium affords admirable meeting places for most events; sections and societies which desire separate rooms have found their needs well met in nearby hotels. Headquarters, auditoriums and banquet halls for all organizations are within easy reach of each other and members will enjoy unusual opportunities for conferences and personal contacts without the expenditure of time often involved in such undertakings at usual meeting places.

Those who have been privileged to attend meetings of the British Association have been deeply impressed by the opportunities offered for social contacts and have felt the value of the associated informal exchange of views between students in different fields. The suggestion has often been made that the American Association could perform a real service by introducing similar features to lighten the pressure of overcrowded programs and intense concentration on individual lines of work. The long distances between hotels and meeting places of different groups in our large cities necessarily limit narrowly such contacts and reduce social influences to lowest terms. Atlantic City is well adapted to permit the enjoyment for the once of a new type of meeting, and the executive committee of the association has planned some unusual features to provide for such an opportunity.

The accessibility of Atlantic City to all parts of the country and the large number of affiliated societies which have arranged to meet there as well as the programs already announced indicate that the meeting will be well attended. Two unusual features call for particular mention in this connection. A special program has been planned for Friday, including a general luncheon for members of all sections and societies at which a distinguished representative of the British Association will address the gathering. Final details for this event will be announced later. On Friday evening there will be a special showing of new films on scientific research.

The association has accepted an invitation from the old and justly famous scientific societies of Philadelphia to adjourn to that city for Saturday. Programs for different groups are being arranged. The American Philosophical Society, the Franklin Institute and the Philadelphia Academy of Natural Sciences are cooperating in the arrangements. A complimentary luncheon and a visit to scientific institutions of the city complete the day's program.

The evening sessions in Atlantic City will follow the usual plan of the association. Monday evening is devoted to the address of the retiring president, Dr. Karl T. Compton, of the Massachusetts Institute of Technology. The Sigma Xi Lecture on Tuesday evening is to be given by Dr. Henry G. Knight, chief of the Bureau of Chemistry and Soils, on the topic, "The Effect of Traces of Selenium in Soils on Plants, Animals and Public Health." The Wednesday evening address, sponsored by the United Chapters of Phi Beta Kappa, will be delivered by President James R. Angell, of Yale, on "The Scholar and the Specialist." On Thursday evening occurs the address of the president of the American

THE MUNICIPAL AUDITORIUM AT ATLANTIC CITY

HEADQUARTERS OF THE AMERICAN ASSOCIATION, WHERE THE PUBLIC LECTURES, MOST OF THE SCIENTIFIC SESSIONS AND THE SCIENCE EXHIBITION WILL BE HELD.

Society of Naturalists, Professor C. E. Allen, of the University of Wisconsin, on "Haploid and Diploid Generations." Afternoon general sessions will include the following: An address by Drs. Zimmerman and Hitchcock, recipients of the Association Prize award at St. Louis, on the subject, "Response of Plants to Hormone-like Growth Substances"; and an address by Dr. C. C. Little, of the Jackson Memorial Laboratory, on "The Social Significance of Cancer." The long series of vice-presidential addresses is distributed over the days from Monday to Friday; their topics, though chosen with regard to the special field of the investigator and his section, appeal also to workers in related fields, often in a wide circle. Thursday afternoon is devoted to the Naturalists' Symposium, for which this year the topic chosen is "Supra-specific Variation from the Viewpoints of Biology and Paleontology."

The programs of the sections and societies are replete with interesting material, and it is impossible to do more than refer to a few items in a brief notice such as this. Symposia and discussions on problems of to-day are included in almost every program, such as those concerning cellular physiology, genetics and development, speed and the airplane, experimental populations, climatic variations and weather predictions, biological effects of radiation, properties of protoplasmic surfaces, radiant energy in the treatment of disease, the cortex and behavior, insects in relation to man.

The Cancer Symposium planned by the Section on Medical Sciences promises to be the most comprehensive presentation on that subject yet worked out and the outstanding event of the meeting. Seven separate sessions extending from Tuesday to Friday inclusive list invited papers on various aspects of the subject which together present a thorough survey of this field. Questions concerning the biological aspects of radiation constitute the first session; the relation of hereditary and constitutional factors to the occurrence of cancer is considered in the second session; two sessions following are devoted to carcinogenic substances, the relationship of sex hormones, the significance of viruses and of inhibitory agents. Thursday will be devoted to tissue culture work and the metabolism of cancerous tissue. On Friday afternoon Dr. Walter Schiller, of Vienna, will lecture on changes in the conception of carcinoma. The tremendous activity manifested in this field of cancer research recently makes this symposium timely for bringing together views on what is a most important problem in human biology.

Several societies have announced special demonstrations, and the Meteorologists plan to send up some unmanned balloons if the weather permits. Finally the science exhibition, which has for years grown in variety and interest, bids fair to be even better this year. It will command the attention of all in attendance at Atlantic City.

HENRY B. WARD,
Permanent Secretary

THE MEETING OF THE FOUNDER SOCIETIES OF THE AMERICAN INSTITUTE OF PHYSICS

A THREE-DAY meeting of all the Founder Societies of the American Institute of Physics took place on October 29, 30 and 31 at the Hotel Pennsylvania, New York City. This was the largest meeting of physicists ever held in America. The actual registration was over 900, but there were perhaps an additional 300 who did not register. Some of the general sessions were attended by approximately 1,000 people.

The societies meeting together were the American Physical Society, Optical Society of America, Acoustical Society

of America, Society of Rheology and the American Association of Physics Teachers. This is the first time that these, the only national physical societies in America, have met simultaneously. They commemorated the fifth anniversary of the American Institute of Physics. Since one of the broad purposes of the institute is to bring about cooperation between pure science and the applications of this science in industries, it was appropriate for this meeting to emphasize industrial physics. Besides the scientific sessions there was a large group of exhibits illustrating applications of physics and instruments used in measuring physical quantities. The most recent text-books in the field of pure and industrial physics were also on display. Much interest was centered around these exhibits, and there were often as many people visiting the exhibits as there were attending the scientific sessions.

One of the features of the meeting was a symposium on the training of physicists for industry. In preparation for this symposium, the American Institute of Physics sent out questionnaires to many prominent industrial physicists inquiring as to which elements in their training have proved most valuable. The many painstaking replies to this questionnaire showed an enormous interest in the kind of preparation an industrial physicist should have and provided much material which was reviewed and classified by the principal speakers at the symposium. Dean Homer L. Dodge, of the University of Oklahoma, discussed this material from the point of view of the educator, while Dr. A. R. Olpin, director of research of the Kendall Mills, interpreted the answers from the point of view of the industrialists. Many valuable facts concerning the training of physicists were brought out in these papers. Industrialists felt that in many cases students were studying too much in the field of atomic and nuclear structure at the expense of fundamental and classical physics. It was their recommendation that more attention be paid to the fundamentals and that most of the specializing be taken up after employment in industry. There is in industry a decided need for men trained in the ability to apply mathematics to physical problems. It is often helpful for those going into industry to study, besides their fundamental physics, a few engineering subjects and especially to have facility with ordinary shop practice and to be able to make simple drawings for design work. Almost as important as a person's technical knowledge in industry is his ability to cooperate with other people. The industries have no use for the brilliant but eccentric and self-centered research scientist. Furthermore, since a man must be able to transmit his ideas to others, the need for better training in the writing and speaking of good English was stressed.

A series of invited papers constituted a symposium on the applications of physics in industry. The need for physicists on the staffs of industrial companies was brought out very clearly by Dr. Zay Jeffries and Dr. E. Q. Adams in their paper on the metal industries, by Dr. E. C. Sullivan in his paper on the glass industry and by Dr. Paul D. Foote in his paper on the oil industry. These men pointed out how great is the need for physical research if other industries wish to follow the great progress which the electrical industry has made in the last fifty years. Dr. Joseph Slepian discussed some of the problems arising in the electrical industry. Some of the phases of physics which can be applied more generally were discussed by Professor J. P. Den Hartog of Harvard in his paper on vibration. He pointed out how important the question of resonance in mechanical systems is and how often such resonance leads to a breakdown at some unexpected time. Dr. Clark Millikan brought out the fact that whenever the margin of safety has

to be drawn very narrow, such as in the airplane industry, where excess weight must be kept to a minimum, the application of physics is especially important. One can not guess at results in this field. He must know exactly how stresses are distributed and where unnecessary parts may be reduced in order to keep the weight down and yet not reduce the safety factor. Dr. Millikan emphasized that more and more in the future a thorough training in the fundamentals of physics will be necessary for an engineer. The vice-president of Bemis Industries, Inc., Mr. John Ely Burchard, discussed the need for greater applications of physics in the building industry. Mr. Burchard felt that here was a wonderful opportunity for the applications of the principles of physics to increase the comfort of the ordinary man. As an example of how physics may contribute to the convenience of mankind in general, Dr. O. E. Buckley, of the Bell Telephone Laboratories, traced in detail the solution of a problem in communication. At every stage in this problem progress was made by the application of physical principles.

Taken as a whole this symposium constituted a very convincing demonstration of the necessity and magnitude of physics in the development of industries. The meeting was attended by a number of non-technical executives whose responsibility it is to control the emphasis placed on research in their corporations.

In line with the purpose of the symposium, the institute announced a new *Journal of Applied Physics*. This journal will replace the old journal, *Physics*, and will carry on the program initiated by its predecessor in the publication of research papers. In addition, new features will be developed which will in many ways alter entirely the character of the journal. Papers describing in a broad way the application of physics in particular industries or in the borderline sciences will be published. Laboratories will be discussed with emphasis on the personnel and organization rather than on the buildings and equipment. Biographical sketches of those who are applying physics will be included. Especially for those in the applied physics field, reviews of recent important articles in other journals will be published along with short sketches concerning the authors of these papers. Great interest was expressed in this new journal and the many advance subscriptions placed constitute an endorsement of its purpose of stimulating the industrial application of physics and serving those engaged in making such applications.

Besides the general symposia on industrial physics, there was also a symposium on the applications of optics in modern science, which was arranged by the Optical Society of America, and a symposium on the nature of the solid state, arranged by the Metropolitan Section of the American Physical Society. The search for new sources of light and the applications of optics in the textile industry and medicine were considered in the former. The latter, on the solid state, brought out the fact that modern atomic structure is being closely related to the ordinary bulk properties of materials.

The intense interest of physicists for research in pure physics was indicated by the fact that there were nearly a hundred contributed short papers. Each of these papers described an advance in some particular phase of physics. Each one when considered by itself perhaps does not represent a very great increase in our knowledge, but when one considers the enormous increase indicated by the total number of papers one can well understand why the period of the last few years has been referred to as the "renaissance of physics."

HENRY A. BARTON,
Director
AMERICAN INSTITUTE OF PHYSICS

PROFESSOR RAYMOND DODGE

AN OIL PORTRAIT BY LLOYD BOWERS EMBRY RECENTLY HUNG IN THE INSTITUTE OF HUMAN RELATIONS.

RETIREMENT OF PROFESSOR RAYMOND DODGE

An oil portrait of Professor Raymond Dodge, presented to Yale University by friends and colleagues of Dr. Dodge, was recently hung in the Institute of Human Relations. Dr. Dodge, who became emeritus last June, was appointed professor of psychology at Yale in 1924, and together with Professors Clark Wissler and Robert M. Yerkes, also appointed the same year, shared in the organization of the Yale Institute of Psychology under the chairmanship of Professor Roswell P. Angier. This institute was a very active research center during the next five years, within which period Dr. Dodge, with the collaboration of his graduate students and assistants, published some twenty scientific papers contributing importantly to such topics as optic nystagmus, inhibition, modification of reflex response, protopraxic and epicritic stratification and conditions of human variability.

In 1929 the Institute of Psychology was merged in the reorganization that resulted in the Yale Institute of Human Relations. In these plans and deliberations Dr. Dodge participated with enthusiasm, spending a large part of one academic year working on laboratory construction plans and in traveling in the United States and Europe on scientific missions. The new institute, when it became a reality, already owed much to Dr. Dodge; and from its opening day he has played a leading rôle in its many-sided activities. The complexities of administrative and committee duties necessarily limited his personal experimental studies in the ideally arranged laboratories of his own design, but through his unfailing counsel and stimulation of younger men within the institute he has multiplied his scientific influence and productiveness during these past few years.

Professor Dodge was the discoverer of fundamental laws in the field of visual perception. In one of his early papers he classified, for the first time, the several types of eye-movements by which visual experience is mediated under varying relationships of the organism and its environment. One line of research flowing from his work has been the eye-movement studies of reading which have developed principles of wide applicability in the teaching of reading in our schools. Another line has led to the development of methods applicable to eye-reflex recording with animals, a field which has been fruitful in studies of learning and conditioning. A third sub-group of his vision studies, that of optic nystagmus, has given results immediately useful in theoretical and clinical neurology. The basic character and wide usefulness of Dodge's results and methods could be illustrated by many examples, and it is earnestly to be hoped that his health will permit him to continue scientific publication from his new residence at Tryon, North Carolina.

The portrait, a reproduction of which accompanies this note, is life-size and shows Dr. Dodge in his laboratory. He is seated by a small table, on which there are several photographic records, and is holding a magnifying lens in his right hand. In the background at the left with its heavy wooded frame depicted in dark red appears a timing instrument. This is a faithful representation of Dodge's historic, and still used, pendulum photo-chronograph, a halftone illustration of which appears at the head of his article, "The Act of Vision," in *Harper's* for May, 1902. In the portrait Professor Dodge is represented as listening with critical attention to some bit of psychological theory that an associate is trying out on him. The artist, Mr. Lloyd Bowers Embry, a recent graduate from the Yale School of Fine Arts, has given us a remarkably successful picture of Raymond Dodge the scientist. The expression is both genial and critical, conveying warm friendliness and at the same time giving something of the stimulating challenge so characteristic of the subject of this portrait.

Walter R. Miles

THE TELEVISION DEMONSTRATION

THE latest television demonstration conducted for representatives of the press by the Radio Corporation of America and the National Broadcasting Company jointly on November 6 focussed attention anew on the field tests in this new art which are proceeding in the New York area. To guests gathered in the RCA Building at Radio City, a forty-minute program illustrating RCA experimental developments was brought by radio.

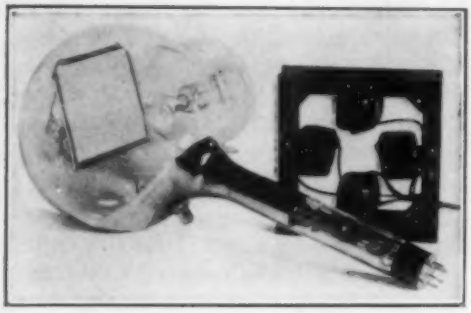
David Sarnoff, president of the Radio Corporation of America, reported on results of the field tests conducted by the company engineers since they were inaugurated on June 29 of this year. Lenox R. Lohr, president of NBC, told of the practical problems presented in staging performances of the air.

Although demonstrations of laboratory television had previously been given, this was the first to be conducted under practical working conditions. It represented the first showing of a complete program built for entertainment value as well as a demonstration transmission. It also included the first showing of a new 12-inch receiving tube, which reproduces a picture on a 7½ by 12-inch screen—the largest screen yet employed.

The program originated in NBC studios in the RCA Building, which are linked by both ultra-high frequency radio and coaxial cable with the transmitter atop the Empire State Building. In this instance reception of the signals from the Empire State transmitter was accomplished in a room on the sixty-second floor of the RCA Building.

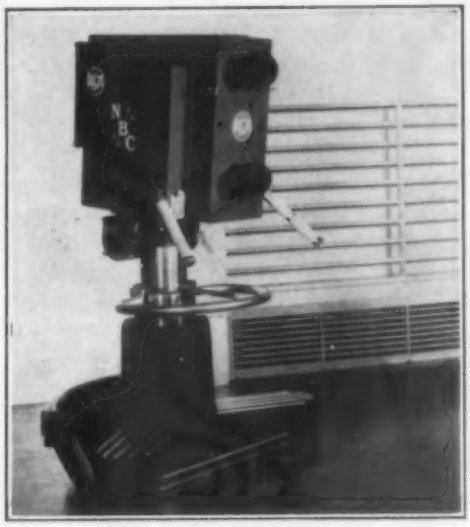
DR. V. K. ZWORYKIN

HOLDING THE "KINESCOPE," OR CATHODE RAY RECEIVING TUBE.



THE "ICONOSCOPE"

THE DEFLECTION OF THE ELECTRON BEAM FOR SCANNING THE MOSAIC IS ACCOMPLISHED BY A MAGNETIC FIELD. THE DEFLECTION COILS ARE ARRANGED IN A YOKE WHICH SLIPS OVER THE NECK OF THE "ICONOSCOPE." THE ASSEMBLED DEFLECTING UNIT IS SHOWN AT THE RIGHT OF THIS PHOTOGRAPH BESIDE THE TUBE.



THE TELEVISION CAMERA

THE CONTROL AT THE LEFT REGULATES THE HEIGHT OF THE CAMERA ON ITS DOLLY. THE CONTROL AT THE RIGHT PROVIDES A RAPID VERNIER CONTROL OF FOCUS. THE LOWER, CENTER LEVER IS FOR STEERING. TWO VIEW FINDERS ARE PROVIDED FOR THE CONVENIENCE OF THE OPERATOR IN FOLLOWING OBJECTS OR SCENES AT DIFFERENT HEIGHTS.

Mr. Sarnoff said that the distance over which the experimental programs had been received exceeded immediate expectations. He reported that in one instance the combination of a location favorable to reception and the extreme height of the transmitter had enabled consistent operation of a receiver forty-five miles from the Empire State Building. Speaking of interferences encountered in the tests, Mr. Sarnoff said that they had been found to be mostly man-made, and therefore susceptible of elimination. He also stated that RCA was planning to rearrange its television transmitting and reception equipment to advance from a basis of 343-line scanning to the higher definition of 441 lines.

The demonstration recalled to many present how rapidly progress had been made in the new art, since all previously developed methods of mechanical scanning were discarded and work begun on the creation of a completely electronic system. The "Iconoscope," or eye of this system, which was developed by Dr. V. K. Zworykin in the RCA laboratories, has been brought to a high state of development. This is the device in which light from the image to be transmitted falls upon a plate covered with hundreds of thousands of tiny, mutually insulated photoelectric particles, each one of which forms one electrode of a condenser which is capable of collecting an electrostatic charge independently of its neighbors. When traversed by an electron beam to accomplish scanning, each condenser gives up its electric charge to produce an electric signal impulse whose intensity varies in proportion to the accumulated charge. That energy is amplified and its product ultimately employed to modulate the television transmitter. The individual photo-electric particles on the plate of the "Iconoscope" are so small that the scanning beam, whose diameter is only a fraction of a millimeter, is calculated to cover more than a hundred of them at any one instant.

The heart of a television receiver in the

RCA system is the "Kinescope," or cathode ray tube. This is the tube in which an electron beam moves across a flat surface of luminescent material in its end, lighting it up as it goes in proportion to the light and shadow of the picture being reproduced.

Some of the work now being done in the RCA laboratories toward the creation of more efficient equipment for television reception was discussed in a paper presented on October 31 before a joint meeting of the American Physical Society and the Optical Society of America by H. W. Leverenz, who is associated with Dr. Zworykin in electronic research. Mr. Leverenz's paper described efforts to produce more efficient luminescent materials, one result of which would be brighter images on screen of a cathode ray tube in a television receiver.

It was apparent from Mr. Leverenz's paper that radio science, not finding needed materials in existence, has had to engage in chemical research, to build special laboratories and to seek to create new combinations of crystalline structures by rearranging their molecules. One fact which this research has already turned up is that absolute purity of materials used in experimentation does not necessarily make for the most efficient results in their use in cathode ray tubes. It is, however, highly important to be able to control very accurately the addition of any foreign or "impure" substances which may make for the production of more light in the tubes. F. M.

THE NON-INHERITANCE OF ALLERGIC DISEASES

THE prevailing concept that the allergic diseases are inherited was refuted by Dr. Bret Ratner, clinical professor of children's diseases at the New York University College of Medicine, in a paper presented before the Association for the Study of Allergy at its fourteenth annual meeting in Kansas City.

His conclusions, based upon investigations covering a period of fifteen years, indicate that susceptibility to allergic diseases is not transmitted through germplasm, or the genes, which are the carriers of hereditary traits. Allergic diseases, including asthma, hay fever, eczema and urticaria, are acquired by the individual under certain circumstances from the inhalation of pollens, animal or vegetable dusts, or contact with them, or from the ingestion of foods.

In an intensive study of 250 allergic children and 315 normal children and their respective families, Dr. Ratner has shown that the incidence of allergy in the family of the allergic child is approximately the same as that of the normal child.

From 7 per cent. to 10 per cent. of the total general population are afflicted. His observations also show that only rarely is there a so-called allergic family in which a large proportion of the members are allergic. About 50 per cent. of the families, both of allergic and normal children, show no allergy in their lineage. There was found to be an average of 2.5 members per family suffering from allergy. No conformity with the simple Mendelian laws of inheritance in allergic case histories was found.

Approximately half of the children studied showed symptoms of allergy in the first year of life and practically all the children manifested their allergic symptoms before the eighth year. The development of allergy in children is to a large extent due to chance. The production of allergic syndromes depends upon the amount of protein to which the individual is exposed, the state of permeability of the mucous membrane which ordinarily acts as a barrier, the ability of the body to rid itself of invading protein substances and the intervals at which such exposures occur.

This concept is borne out by many

years of experimental work in which Dr. Ratner and his coworkers actually produced asthma in the guinea pig. This was consummated by subjecting the animals to a special environment containing antigenic dusts. The animals inhaling such a dust show no symptoms after several hours' exposure. When returned to the same environment two or three weeks later these animals develop dyspnea and show all the symptoms of asthma. The reproduction of a disease such as asthma, under experimental conditions, precludes the necessity for regarding it as dependent upon hereditary factors.

Dr. Ratner and his coworkers also demonstrated that a child may become sensitized in the uterus of the mother as a result of undigested food proteins entering her circulation and thence traversing the highly permeable placenta, and thus invading the fetal circulation. Children manifesting allergic symptoms upon first contact with a new food have not necessarily inherited such an intolerance, but have acquired their allergic state congenitally.

The hope held out by these studies is that in so far as susceptibility to allergic diseases is not proven to be inherited through germ plasm, proper preventive measures can be instituted to control and to a large extent eradicate this common ailment which is present in every tenth person. M. S.

METHYLENE BLUE AS AN ANTIDOTE FOR CYANIDE AND CARBON MONOXIDE POISONING

In former days potassium cyanide was notorious as a fatal poison. It has the property of uniting with the hemoglobin or red coloring matter of the blood and of preventing it from transferring oxygen to the tissues. Since the tissues can not survive without oxygen, asphyxiation and death take place. In 1932 it was announced by the writer at the University of California, Berkeley, California, that the aniline dye, methylene blue, should be used as an antidote for cyanide poisoning. This was deduced theoretically from a study of evidence gathered from experiments of other scientists, together with those which the writer performed on rats and rabbits.

This dye has been used for purposes of staining in histology for a long time. There are several impure varieties or unsuitable forms such as the double zinc salt which should be avoided. Only U.S.P. medicinal or chemically pure dyes should be used. The solution is most effective when made up fresh before using. Preferably the amount of dry dye to be used should be on hand and the mixing in distilled water should be done just before using, as an aqueous solution oxidizes rapidly. An intravenous injection of 50 cc of a 1 per cent. solution is usually successful. In some cases a second dose or even more may be administered after a short interval of time.

Physicians have been slow to adopt this therapy. A few months after the writer's announcement at a meeting of the Society for Experimental Biology and Medicine in Berkeley that methylene blue should be used in cases of cyanide poisoning, three policemen were brought into the emergency ward of a San Francisco hospital poisoned by liquor. There was a distinct odor of cyanide about them, and the stomach contents showed that cyanide was present. The old methods outlined in the texts failed to produce any revival and the men died. The methylene blue treatment had not yet been recognized by the American Medical Association, and the information was therefore not available to physicians.

A few months after this a despondent student took cyanide and was likewise

brought into the emergency ward. Dr. Geiger, the physician in charge, telephoned various people to find out what to do and happened to call one of the men who had heard about this treatment. Nothing was to be lost in administering the methylene blue as the man was almost dead. His respiration had stopped and the heart sounds were barely audible. He was cyanosed and cold. Quickly they mixed up a 1 per cent. solution of methylene blue and injected it intravenously. Before the injection was completed the man began breathing, regained consciousness, opened his eyes and talked. In a few hours he was normal and told his story of disappointment. Since this first case a number of others have been revived from death by cyanide poisoning. The latest case was that of a man who drank two ounces of hydrocyanic acid in San Francisco last June. He was brought to the operating table one half hour afterwards, rigid and motionless. The breathing had stopped and no pulse beat could be detected. After the injection of methylene blue he recovered rapidly. This was the first case in which a man has lived after drinking the poison in the acid form.

Since hydrocyanic acid is used in the mining of gold, in spraying fruit trees and in fumigation of ships, accidents can be minimized by having this antidote ready in case of emergency.

It has also been found by the writer that methylene blue is an antidote to carbon monoxide poisoning and has been used in resuscitating a number of victims. Since the affinity which hemoglobin has for carbon monoxide is about 300 times that for oxygen, the hemoglobin is unable to function in transferring oxygen. Without oxygen, life can not go on; the tissues become asphyxiated and death results. In addition to the fact that the hemoglobin can not function, the respiratory enzyme which is a link in the transfer of oxygen to the tissues is poisoned and the chain of oxidation is stopped at this point also. Methylene blue, which acts as an oxygen carrier by virtue of its ability to become reversibly oxidized and reduced, presumably takes the place of the hemoglobin and the respiratory enzyme until these are able again to perform their normal functions.

The importance of prompt treatment, especially in the case of carbon monoxide poisoning, is seen when one considers the effects of oxygen lack on such sensitive cells as are found in the brain and kidney. Irreversible injury takes place in a very short time. Permanent damage may result in loss of memory or improper elimination by the kidney. The injection of methylene blue hastens recovery and eliminates the long delay involved when carbon monoxide poisoning is treated by the inhalator method. In the *Journal* of the American Medical Association is the history of several cases treated by methylene blue with controls which happened to be present. In the one instance two victims of carbon monoxide poisoning were brought into the emergency ward; the more severe one was given the methylene blue injection while the other one was not treated by this method. The latter required many hours to recover and was still suffering from the effects while the former had completely recovered. In another instance, five victims were taken to the hospital at Los Angeles. The two most severe cases were given the methylene blue injection and the others were not, with the result that the treated cases recovered, while those not receiving treatment were still suffering from the poison.

In conclusion it may be stated that, in cases of poisoning by either cyanide or carbon monoxide, methylene blue injections have been shown experimentally and clinically to be an effective antidote.

MATILDA MOLDENHAUER BROOKS

INDEX

NAMES OF CONTRIBUTORS ARE PRINTED IN SMALL CAPITALS

ABBOT, C. G., Solar Variability and Weather, 108
Agricultural Recovery and the Soybean, A. A. HORVATH, 63
Alchemy, Origins of, T. L. DAVIS, 551
Allergic Diseases, Non-inheritance of, 584
Alloys, Fusible, S. J. FRENCH, 205
Altitudes, High, Physiology of Life at, A. KEYS, 289
AMBROSIUS, E. E., and J. C. REED, James Watt, 272
American Association for the Advancement of Science, Rochester Meeting, J. E. HOFFMEISTER, 84; Christmas Meeting, 575
Anesaki, Masaharu, Portrait, 486
Animals, and Plants, W. P. TAYLOR, 262
Antiquity of Man, E. B. HOWARD, 367
Arboreta, Old and New, J. G. JACK, 541

B., L. C., Sigma Xi Semi-Centennial, 184
BEARCE, H. W., Weights and Measures, 566
BEARD, J. H., Cholera and Public Health, 515
Bergius, Friedrich, Portrait of, 485
Birth Rate, Argentine, and World's Food, S. G. HANSON, 559
BOK, B. J., American Astronomical Society, 375
British Association at Blackpool, 382

C., E. D., Awards of Franklin Medals, 181
C., H. T., Biological Sciences at the Harvard Tercentenary Conference, 378
Calendar and Zero, R. M. WINGER, 363
"Cellulose," the Structure of, 94
Children, Protecting from Depression Disturbances, I. N. KUGELMASS, 74
Cholera and Public Health, J. H. BEARD, 515
Cicada, Emergence of, W. W. COBLENTZ, 239
COBLENTZ, W. W., Emergence of the Cicada, 239
COLLIP, J. B., Hormones, 411
Compton, Arthur Holly and Karl Taylor Compton, Portrait, 490
Conant, James B., Portrait, 276
Conservation among Primitive Hunting Peoples, W. C. MACLEOD, 562
COOPER, L., Galileo and Scientific History, 163
Cosmic-ray Researches, R. A. MILLIKAN, 396
Cosmology, Status of, R. C. TOLMAN, 491
Cotton Plant, A. R. MACORMAC, 285
Creative Years in Science and Literature, H. C. LEHMAN, 151
Culture and Behavior, B. MALINOWSKI, 440

DAVIS, T. L., Origins of Alchemy, 551
DEAN, H. T., Action of Fluorides on Human Teeth, 191
DEMEREČ, M., Genetics Society of America, 380
Dietary Habits, R. E. REMINGTON, 193
DILLE, J. M., Early Photography in the Medical Sciences, 224
DODD, S. C., A Theory for the Measurement of Social Forces, 58
Dodge, Raymond, Retirement, 581
Drought, 1936, Meteorological Aspects, W. R. GREGG, 190; J. B. KINCER, 191

Eclipse Expedition to the U. S. S. R., 91
EDDINGTON, A. S., Constitution of the Stars, 385
Eddington, Arthur Stanley, Portrait, 376, 485
Electric Currents in the Earth, O. H. GISH, 47
Electrical, Potential in the Cortex of the Brain, Fluctuations of, 95; Communications, Scientific Research in, F. B. JEWETT, 466
Evolution, Mammalian, W. B. SCOTT, 421; Economic, W. C. MITCHELL, 450

Fish Teratology, E. W. GUDGER, 252
FISHER, R. A., Uncertain Inference, 402
Fluorides, Action on Human Teeth, H. T. DEAN, 191
Fossils in Pennsylvania, B. WILLARD, 335
FRENCH, S. J., Fusible Alloys, 205
FULLER, W., Harvard Tercentenary of Arts and Sciences, 480

Galileo and Scientific History, L. COOPER, 163
GALTSOFF, P. S., and OTHERS, Effect of Crude Oil Pollution on Oysters in Louisiana Waters, 70
Genetics, Modern, H. H. LAUGHLIN, 244; Society of America, M. DEMEREČ, 380
GIBSON, R. E., Solutions under High Pressure, 173
GISH, O. H., Electric Currents in the Earth, 47
Gorillas, in Quest of, W. K. GREGORY, 23, 130, 211, 313, 522; Hunting in West Africa, H. C. RAVEN, 313; Men and Sleeping Sickness, H. C. RAVEN, 522
GREENE, J. D., Harvard Tercentenary Conference, 277
GREGG, W. R., Meteorological Aspects of the 1936 Drought, 190
GREGORY, W. K., In Quest of Gorillas, 23, 130, 211, 313, 522
GUDGER, E. W., Fish Teratology, 252

HAAS, W. H., The Jíbaro, 33
HANSON, S. G., World's Food and the Argentine Birth Rate, 559
Harvard Tercentenary, 385–490, 477; Conference, J. D. GREENE, 277; American Astronomical Society, B. J. BOK, 375; the Biological Sciences, H. T. C., 378; Conference of Arts and Sciences, W. FULLER, 480
HOFFMEISTER, J. E., Rochester Meeting of the American Association, 84
Hormones, J. B. COLLIP, 411
HORVATH, A. A., Soybean and Agricultural Recovery, 63
HOWARD, E. B., Antiquity of Man in America, 367
HUMASON, M. L., An Expanding Universe, 80

Indian, American, Length of Life of, C. WISSLER, 5

Inference, Uncertain, R. A. FISHER, 402
Intellect, Training, B. R. SIMPSON, 346
IRVING, L., Relation of Organisms to the Salts of the Ocean, 508

JACK, J. G., Arboreta, Old and New, 541
Janet, Pierre Marie Felix, and Mme. Janet, Portrait, 489
JEWETT, F. B., Electrical Communications, 466
Jewett, Frank B., Award of Franklin Medal, 181, Portrait, 183
Jíbaro, The, W. H. HAAS, 33

Kettering, Charles F., Award of Franklin Medal, 181, Portrait, 182
KEYS, A., Physiology of Life at High Altitudes, 289
KINCER, J. B., Effect of 1936 Drought on Crops, 191
KRAUS, C. A., Arthur Amos Noyes, an Appreciation, 179
KUGELMASS, I. N., Protecting Children from Depression Disturbances, 74

LAUGHLIN, H. H., Modern Genetics, 244
LEHMAN, H. C., Creative Years in Science and Literature, 151
Life of American Indian, C. WISSLER, 5
Lowell, A. Lawrence, Portrait, 480

MACLEOD, W. C., Conservation among Primitive Hunting Peoples, 562
MACORMAC, A. R., Utilization of the Cotton Plant, 285
MALINOWSKI, B., Culture and Behavior, 440
Medals, Franklin, Awards, E. D. C., 181
MERRILL, E. D., Plants and Civilization, 430
MILLIKAN, R. A., Cosmic-Ray Researches, 396
MITCHELL, W. C., Intelligence and the Guidance of Economic Evolution, 450

National Academy of Sciences, Medallists, F. E. WRIGHT, 87
Noyes, Arthur Amos, Portrait, 178; Appreciation, C. A. KRAUS, 179
Nutritional Improvement, H. C. SHERMAN, 97

Ocean, Salts of, and Organisms, L. IRVING, 508
Olympic Games, Winners, C. D. SNYDER, 372
Oysters, Effect of Oil Pollution on, P. S. GALTSOFF and OTHERS, 70

Pannekoek, Antonie, Portrait, 376; and Mrs. Pannekoek, 488
PERKINS, E. B., Plankton and Invertebrates of the Antarctic, 568
Photography in the Medical Sciences, J. M. DILLE, 224
Physicists' New Delusion, M. SCHOEN, 358
Physics, American Institute of, Meeting of the Founder Societies, 577
Physiology of Life at High Altitudes, A. KEYS, 289
Plankton and Invertebrates of the Antarctic, E. B. PERKINS, 568
Plants and Civilization, E. D. MERRILL, 430
Poisoning, Carbon Monoxide and Cyanide, 585
Progress of Science, 84, 178, 276, 375, 477, 575

RAVEN, H. C., Gorillas, Hunting in West Africa, 313; Men and Sleeping Sickness, 522
REMINGTON, R. E., Dietary Habits, 193
Rhythms, Irrational, J. B. SHAW, 168
Russell, F. F., Public Welfare Medal, 87, Portrait, 89

Saha, Megh Nad, Portrait, 377
SCHOEN, M., Physicists' New Delusion, 358
Scientific Method, E. J. WITZEMANN, 122
SCOTT, W. B., Mammalian Evolution, 421
Shapley, Harlow, Portrait, 377
SHAW, J. B., Irrational Rhythms, 168
SHERMAN, H. C., Nutritional Improvement, 97
Shih, Hu, Portrait, 486
Sigma Xi Semi-Centennial, L. C. B., 184
SIMPSON, B. R., Training the Intellect, 346
SNODDY, G. S., The Learning Process, 287
SNYDER, C. D., Winners in Olympic Games, 372
Social Forces, S. C. DODD, 58
Solutions under High Pressure, R. E. GIBSON, 173
Spectroscopy and Its Applications, 283
Stamp, Josiah, Portrait, 383
Stars, Constitution of, A. S. EDDINGTON, 385
STETSON, H. T., Influence of Sun on Human Affairs, 14
Stomach as an Organ of Social Adjustment, T. W. TODD, 341
Sun, Influence on Human Affairs, H. T. STETSON, 14

TAYLOR, W. P., Effects of Animals on Plants, 262
Television Demonstration, 582
Thumb of Man, E. L. TROXELL, 148
Time, Rôle of, in Learning Process, G. S. SNODDY, 287
TODD, T. W., The Stomach as an Organ of Social Adjustment, 341
TOLMAN, R. C., Status of Cosmology, 491
TROXELL, E. L., The Thumb of Man, 148

Universe, Expanding, M. L. HUMASON, 80

Vaughan, T. Wayland, Medal for Oceanography, 87; Portrait, 88

Watt, James, E. E. AMBROSIUS and J. C. REED, 272
Weather, Solar Variability and, C. G. ABBOT, 108
Weights and Measures, H. W. BEARCE, 566
Whiting, P. W., Portrait, 380
WILLARD, B., Fossils in Pennsylvania, 335
Williams, Henry S., Portrait, 185
WINGER, R. M., Zero and the Calendar, 363
WISSLER, C., Life of the American Indian, 5
WITZEMANN, E. J., Scientific Method, 122
WRIGHT, F. E., Medallists of the National Academy of Sciences, 87

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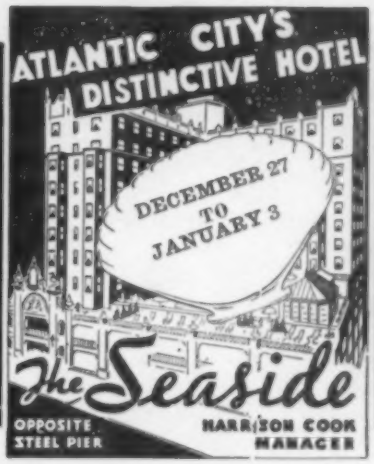

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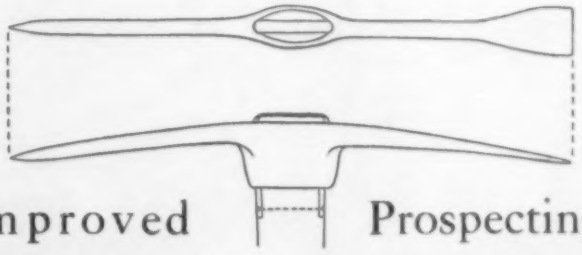

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